FOR

MARINE DIESEL GENERATING PLANTS

15 KW

SERIES

DIRECT CURRENT MODELS

ALTERNATING CURRENT MODELS

DUAL PURPOSE MODELS

ONAN
2515 UNIVERSITY AVE. S.E. MINNEAPOLIS, MINN. 55414
A DIVISION OF STUDEBAKER CORPORATION
IN CANADA: ONAN GENERATORS CANADA LTD., P.O. BOX 662, GUELPH, ONTARIO

Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC–rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work–harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.
- Warning: Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [–] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (–) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocution can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [–] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or allow skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [–] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stowed gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

LIST OF ILLUSTRATIONS

PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

The engine of your generating plant makes as many revolutions in one hour, as the average automobile engine does when the car travels a distance of 41 miles.

100 running hours time on a generating plant engine is equivalent in total RPM's to approximately 4100 running miles on an automobile.

However, do not conclude that the wear on the generating plant engine and the wear on the automobile engine would be the same. The generating plant engine is built much more ruggedly, (having larger main bearings, bigger oil capacity and has a heavier crankshaft proportionately per horsepower) than most automobile engines. Given the proper care and periodic servicing the generating plant engine will continue to give many more hours of efficient service than an automobile engine will after having been run the equivalent number of running miles.

Compare the running time of your generating plant engine with the number of miles traveled by an automobile. The oil in an auto is checked every one or two hundred miles (3 to 5 hrs. running time) and changed every 1000 to 1500 miles (28 to 42 hrs.) whereas in a generating plant or stationary power engine, the oil should be checked every 6 to 8 running hours (250 to 350 miles) and changed every 50 to 100 operating hours (2000 to 4000 miles) depending on operating conditions.

About every 5,000 to 10,000 miles (120 to 250 hours), services have to be performed on an auto, such as checking ignition points, replacing spark plugs, condensers, etc. Similarly on your generating plant engine, these same services have to be performed periodically except the change period is reckoned in hours. 10,000 miles on an auto is equivalent to about 250 running hours on your plant engine.

To arrive at an approximate figure of comparative generating plant running hours as against automobile engine running miles, multiply the total number of running hours by 41 to find the equivalent of running miles on an automobile.

Your generating plant engine can "take it" and will give many hours of efficient performance provided it is serviced regularly.

Below is a chart showing the comparison between a generating plant engine running hours and an automobile running miles.

	GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES
DAILY AVERAGE	1 Hr.	41 Miles
	4 Hrs.	164 "
	6 "	246 "
	8 "	328 "
WEEKLY AVERAGE	7 "	287 "
	28 "	1,148 "
	42 "	1,722 "
	56 "	2,296 "

	GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES
MONTHLY AVERAGE	30 Hrs.	1,230 Miles
	120 "	4,920 "
	180 "	7,380 "
	240 "	9,840 "
YEARLY AVERAGE	365 "	14,965 "
	1,460 "	59,860 "
	2,190 "	89,790 "
	2,920 "	119,720 "

NOTE: Electric generating plants do not operate economically when used to power electric refrigerators and will add from 4 to 8 operating hours per day in addition to the regular lighting load.

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GENERAL INFORMATION

THIS INSTRUCTION BOOK CONTAINS INFORMATION FOR THE PROPER INSTALLATION, OPERATION AND MAINTENANCE OF YOUR EQUIPMENT. WE SUGGEST THAT THIS BOOK BE KEPT HANDY SO THAT IT CAN BE REFERRED TO WHEN NECESSARY.

THIS EQUIPMENT IS THE RESULT OF PROVEN ENGINEERING DESIGN, HIGHEST QUALITY MATERIALS, AND EXPERT WORKMANSHIP. THOROUGH INSPECTION AND TESTING ASSURES YOU THAT THIS EQUIPMENT WILL PERFORM AS EXPECTED.

IF YOU WISH TO CONTACT YOUR DEALER OR THE FACTORY REGARDING THIS EQUIPMENT, BE SURE TO SUPPLY THE COMPLETE MODEL AND SPEC. NO., AND THE FULL SERIAL NUMBER OF THE EQUIPMENT AS SHOWN ON THE NAMEPLATE. THIS INFORMATION IS NECESSARY TO IDENTIFY THE EQUIPMENT AMONG THE MANY BASIC AND SPECIAL OPTIONAL TYPES MANUFACTURED.

TABLE OF CONTENTS

The ONAN MDSP Series Marine Diesel powered electric generating plants to which this manual applies are complete electric generating plants. Each plant includes an engine, generator, and necessary accessories. Each plant is thoroughly tested before leaving the factory to assure that all parts are in good condition and that each plant will produce its rated output.

The manual contains instructions on installing, operating, servicing, adjusting, and repairing your plant. Read all instructions carefully. Correct installation, operation, and servicing are important in assuring long life operation. Disregarding these instructions may lead to unnecessary trouble and expense.

TYPES OF PLANTS

Standard models of the alternating current plants, dual purpose plants, and battery charging plants are covered in this manual. These plants differ mainly in the type of current generated. Where standard model differences in connecting, installing and servicing occur, they will be treated separately.

This instruction manual is supplied with all generating plants of the MDSP series. Instructions apply specifically to the standard models. Some details may not apply to special models. Some special installation or operating conditions may require the operator of this plant to modify these instructions. A model specification other than those shown for standard plants in the Data Table below indicates an addition of, or a change in, one or more optional features of the plant. However, by following as closely as possible the recommendations as given in this book, the operator should have no difficulty in making a good installation and in properly operating the generating plant. If the special difference is electrical, refer to the special wiring diagram for that plant rather than the wiring diagrams shown in the rear of this manual.

PLANT DATA TABLE

PLANT DESIGNATION			ELECTRICAL OUTPUT						TYPE
MODEL	SPEC.		WATTS	VOLTS	CYCLES	WIRE	PHASE		CURRENT
3MDSP-1R	1	A, B, C, D.	3,000	115	60	2	1	†	AC
205MDSP-51R	1		2,500	115	50*	2	1	†	AC
3MDSP-3R	1		3,000	115/230	60	3	1	†	AC
205MDSP-53R	1		2,500	115/230	50*	3	1	†	AC
3MDSP-1R4	4		3,000	115	60	2	1	†	DUAL PURPOSE
				32	DC				
3MDSP-232R	1		3,000	32	DC	2		††	BATTERY CHARGER
205MDSP224R	1		2,500	24	DC	2		††	

† - GROUNDED electrical system. †† - UNGROUNDED electrical system.

* - Note: The main difference between the 50 cycle plant and the 60 cycle plant is in the current frequency. Most electrical appliances can be used on either frequency but it is advisable to check appliances for use with 50 cycle plants before purchasing to assure that they are adaptable to the frequency of the current.

ALTERNATING CURRENT PLANTS. - Plants of the alternating current type produce their full rated capacity in alternating current (ac) plus 150 watts of direct current (dc) which is used for battery charging purposes. The plant must be operated whenever alternating current is used. A small auxiliary load may be taken from the starting battery for short periods of time while the plant is idle. Always have the battery connected when operating the plant.

DUAL PURPOSE PLANTS. - Plants of the dual purpose type produce 115 volt alternating current and 32 volt direct current. The total capacity of 3000 watts may be taken from the plant in alternating current or up to 750 watts may be taken in direct current and the balance of 2250 watts in alternating current. Alternating current is supplied directly to the load from the generator and the plant must be operated whenever alternating current is used. Direct current is supplied directly to the load from the battery and direct current may be used while the plant is running, or as limited by the charge in the battery, while the plant is not running. NEVER OPERATE THIS TYPE OF PLANT WITHOUT HAVING THE BATTERY CONNECTED. The battery specific gravity should be checked at frequent intervals duringHIGH charge rate operation. As the battery reaches a fully charged condition the operator must snap the charge rate switch to LOW position. CONTINUOUS OPERATION AT HIGH CHARGE RATE AFTER THE BATTERY IS FULLY CHARGED MAY BURN UP THE BATTERY.

BATTERY CHARGING PLANTS. - Plants of the battery charging type are operated to generate electricity which is supplied directly to the storage battery. Electricity may be used while the plant is running or, as limited by the charge in the battery, while the plant is not running. NEVER OPERATE THIS TYPE OF PLANT WITHOUT HAVING THE BATTERY CONNECTED. AS THE BATTERY BECOMES CHARGED, THE OPERATOR MUST TURN THE RHEOSTAT TO THE LOW CHARGE RATE POSITION. CONTINUOUS OPERATING AT HIGH CHARGE RATE AFTER THE BATTERY IS FULLY CHARGED WILL BURN UP THE BATTERY! Repeated adjusting of the rheostat to gain a tapering off charge rate is desirable.

ENGINE

TYPE. - 4 cycle; vertical single cylinder; 3-1/2" bore; 3-1/2" stroke; 33.7 cubic inch piston displacement; 18.5 to 1 compression ratio; 5.5 horsepower at 1800 rpm; water-cooled (solid injection) full Diesel.
CYLINDER-CRANKCASE. - Cast integral to form a sturdy one-piece unit. Cylinder water jacket conducts heat rapidly from cylinder to maintain normal operating temperature. Ventilated crankcase.

CYLINDER HEAD. - Cast iron, stress relieved. Water jacket removes heat to maintain normal operating temperature, glow plug incorporated for cold weather starting.
VALVES. - Special alloy steel; overhead type. Replaceable exhaust valve seat insert. Valve adjustment at rocker arm.
PISTON. - Aluminum alloy, 5 ring. Full floating piston pin.
CRANKSHAFT. - Extra heavy unusually rigid, fully counter-weighted, cast-in tubular oil passages.
BEARINGS. - Main bearings are aluminum alloy, 2-3/4" diameter; Connecting rod bearings are aluminum alloy, 2-3/8" bearing surface, precision type.
LUBRICATION. - Gear type oil pump; main and connecting rod bearings, rocker arms, and water pump pressure lubricated, all other internal moving parts splash lubricated; Non-adjustable oil pressure relief valve; by-pass type oil filter; 4 quart oil capacity(U.S. measure) excluding filter.
FUEL SYSTEM. - Diaphragm type transfer pump; dry type air silencer; (cleaner); primary fuel filter with permanent type cleanable element and secondary fuel filter with replaceable element; cam operated high pressure, throttling type injection pump; solid injection type nozzle (1750 lbs. nozzle pressure).
IGNITION. - By compression.
GOVERNOR. - Enclosed centrifugal ball type; accessible for adjustment.
COOLING. - Water cooling circulated by an impeller type gear driven water pump; temperature controlled by thermostat and by-pass.
STARTING. - 12-volt electric starting for ac units. 32 volt electric starting for 32-volt battery charging units and dual purpose units. The generator acts as a powerful cranking motor.

GENERATOR

All of the standard model plants are rated 3,000 watts and operate at 1800 rpm except the 50 cycle ac plants which are rated at 2,500 watts and operate at 1500 rpm. Output data appears on the plant nameplate. The generator is of the four pole, self-excited, saturated field, inherently regulated, revolving armature type. On the alternating current generator, both the ac and dc windings fo the armature are wound on the same laminations, the ac windings connecting to the collector rings, the dc windings to the commutator. The field coils are saturated shunt wound. The armature is directly connected to the engine crankshaft and turns at engine speed. The armature is supported at the inner end by the rear main bearing and at the outer end by a ball bearing. The frame is a rolled steel ring, machined on the inside, in which the poleshoes and coils are mounted. A removable band provides for easy access to the generator brushes.

CONTROLS

All models are remote starting. However, if it is necessary to preheat by means of the glow plug, this can be done only while at the plant, by holding the glow plug switch at ON position.

Provisions are furnished for emergency hand cranking.

Most controls are located in the control box mounted on the generator.

Controls for the alternating current or for the dual purpose plants include a charge relay, charge rate ammeter, start-stop switch, a manual switch to operate the glow plug, a high-low charge rate switch, glow plug relay, decompression release solenoid operating relay, start solenoid, high-water-temperature cut-off switch, oil pressure cut-off switch, decompression release solenoid (on cylinder head), and various resistance units.

Controls for the battery charging plants include a charge rate ammeter, a start-stop switch, a glow plug (preheat) switch, a reverse current relay, start solenoid, decompression release solenoid operating relay, glow plug relay, decompression release solenoid (on cylinder head), oil pressure switch, high-water-temperature cut-off switch, and a rheostat for controlling the charging rate to the battery.

The decompression release that operates to disengage with the exhaust valve during the starting cycle is located on the cylinder head. The glow plug which aids in cold weather starting by helping ignite the fuel is located on the cylinder head. On plants with 24 or 32 volt cranking a manifold heater is used in conjunction with the glow plug.

STANDARD EQUIPMENT

Vibration dampeners and spill pan; primary and secondary fuel filters; lubricating oil filter; dry type air cleaner; exhaust silencer(muffler); hand crank; flexible fuel lines; coolant thermostat; timing gauge for injection pump tappet.

CAUTION !

CONTINUOUS OPERATION AT HIGH CHARGE RATE, WHEN THE BATTERY IS FULLY CHARGED, MAY "BURN UP" THE BATTERY !

THE BATTERY INTERNAL RESISTANCE INCREASES AS THE BATTERY REACHES A FULLY CHARGED CONDITION, CAUSING A DESIRABLE TAPERING OFF CHARGE RATE. HOWEVER, THE BATTERY SPECIFIC GRAVITY MUST BE CHECKED FREQUENTLY DURING OPERATION AT HIGH CHARGE RATE.

THE PLANT MAY BE OPERATED CONTINUOUSLY AT LOW CHARGE RATE WITHOUT DAMAGING A FULLY CHARGED BATTERY.

GENERAL. - Due to the great variation in the design of hulls and the varied location of compartments suitable for the installation of an electric generating plant, the instructions given here must necessarily be of a general nature. However, the basic principles outlined in these instructions should be complied with. The proper installation of the plant is absolutely necessary for safe, satisfactory and continuous service.

LOCATION. - The plant shall be mounted in a dry, accessible and properly ventilated location. Locate the plant as high as practicable to avoid damage by splash from the bilage or by coming in contact with low lying vapors. The plant should never be located in low pocketed positions.

The plant should be secured to a strong support, preferably centered as near as possible to the boats main keel. Maintain reasonable accessibility for minor servicing operations, hand cranking, draining of the crankcase lubricating oil and draining of the plant spill pan.

MOUNTING THE PLANT. - Bolt the plant firmly to its mounting base at the four corners. The plant is shock mounted between the plant proper and the pan and other shock absorbing cushions are not needed.

The four mounting holes in the spill pan are 1/2" and are located 16" between centers front to rear and left to right.

SHOCK MOUNTING. - Check the shock mounting cushions for tightness. The screws securing the cushions should be tight. The two larger vibration dampeners are used on the generator end of the base.

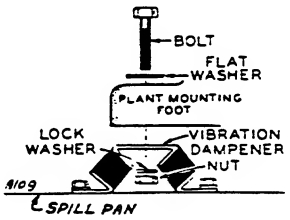


FIG. 1 - VIBRATION DAMPENER

VENTILATION. - An internal combustion engine must have a free circulation of air while operating. The location should be such that there will be proper ventilation for exhausting of any gases. Any compartment or space in which an engine is located, particularly if it is in the lower portion of the hull or bilge, should be provided with means for ventilation to effectively remove any possible accumulation of inflammable or explosive vapors. Fuel tank compartments should be similarly

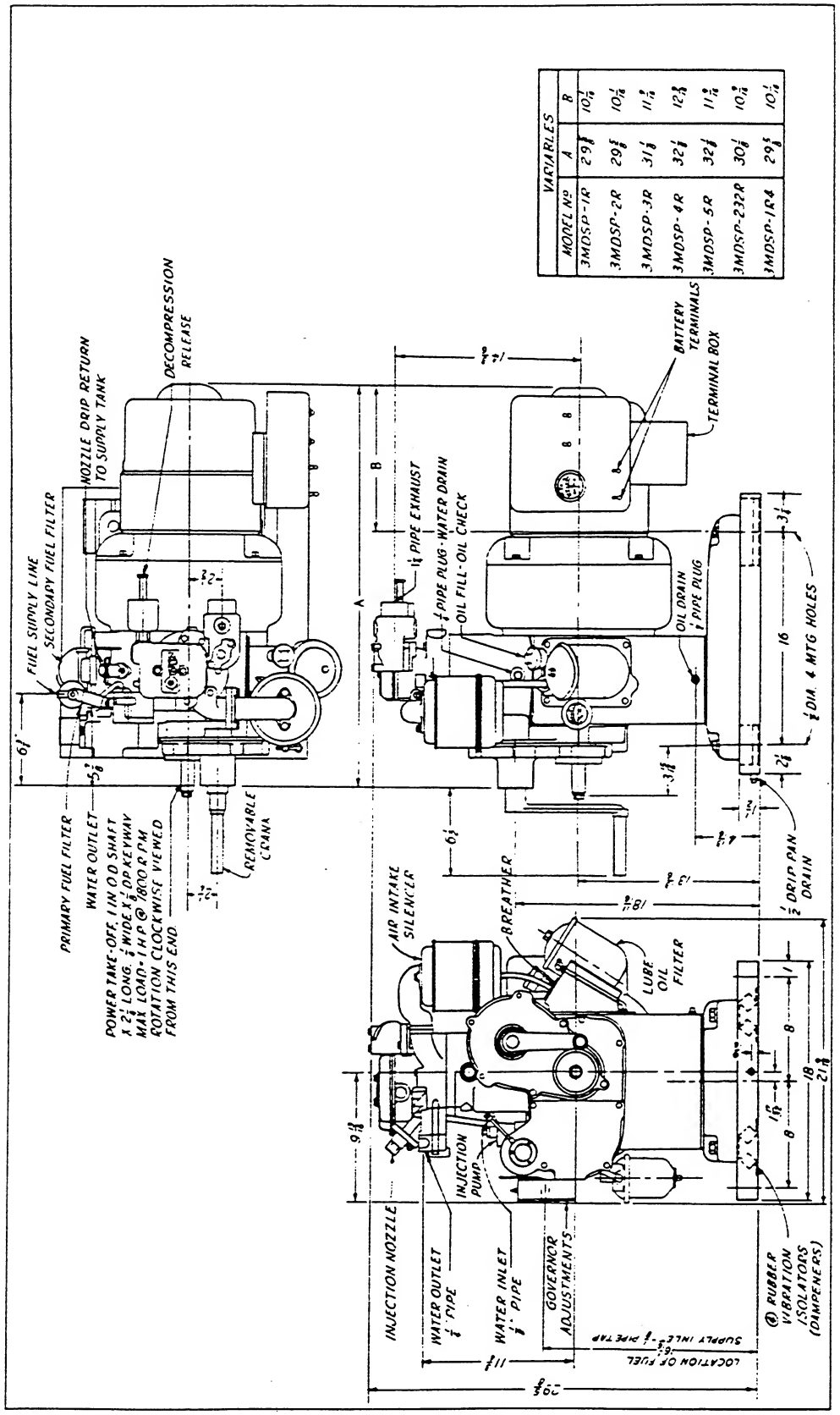


FIG. 2 - DIMENSIONAL OUTLINE

ventilated. It will be found that most craft have provisions for adequately disposing of fuel vapors out of the engine compartmemt and bilge and can also accommodate the exhausting of any additional vapors emanating from the electric generating plant. If they do not have such provision, the following is recommended.

1. Where the generating plant or fuel tanks are located in closed compartments, permanently open and adequate inlet and outlet ventilating ducts extending to the bilges should be installed; two inlets leading to the wings at one end of the compartment and two outlets from the wings at the opposite end.

2. Where the plant or fuel tank is not located in a closed compartment, at least one such duct should be installed in the fore part of the boat and one in the aft part.

Inlet ducts should be provided with cowls or equivalent fittings. Where feasible, it is also recommended that the outlet ducts be fitted with wind actuated, self turning or rotary exhauster heads, or that power operated exhausters be installed in each outlet duct. If power operated exhausters are used, motors should be installed outside of the ducts and as high above the accommodation flooring as practicable. Such exhausters should be run for at least 5 minutes before starting any engine. Size of vents should be about proportional to the beam of the boat with two square inches of aggregate vent area per foot of beam as a minimum.

EXHAUST PIPE AND MUFFLER. - The installation of the exhaust pipe and water cooled muffler must necessarily be governed by the location of the generating plant but there are some requirements that must be met. Install a completely separate exhaust line. Do not connect to any other engine exhaust line. All of the engine cooling water should be discharged through the exhaust line and enter at a point as near the engine manifold as practicable. Where the first twelve diameters or more of the exhaust are neither jacketed nor cooled by the entire discharge of the engine circulating water, woodwork within 6 inches of any part of the exhaust shall be protected by 1/8 inch asbestos board covered with sheet metal. A dead air space of 1/4 inch shall be left between the protecting asbestos and the wood and a clearance of not less than 1/2 its diameter shall be maintained between the exhaust line and the surface of such protection. The portion of the exhaust line not cooled by water shall be covered with heat insulating material. Where the exhaust line passes through water tight bulkheads, non-combustible packing should be installed. The exhaust line should be led to the point of escape through the hull with a minimum number of bends or elbows.

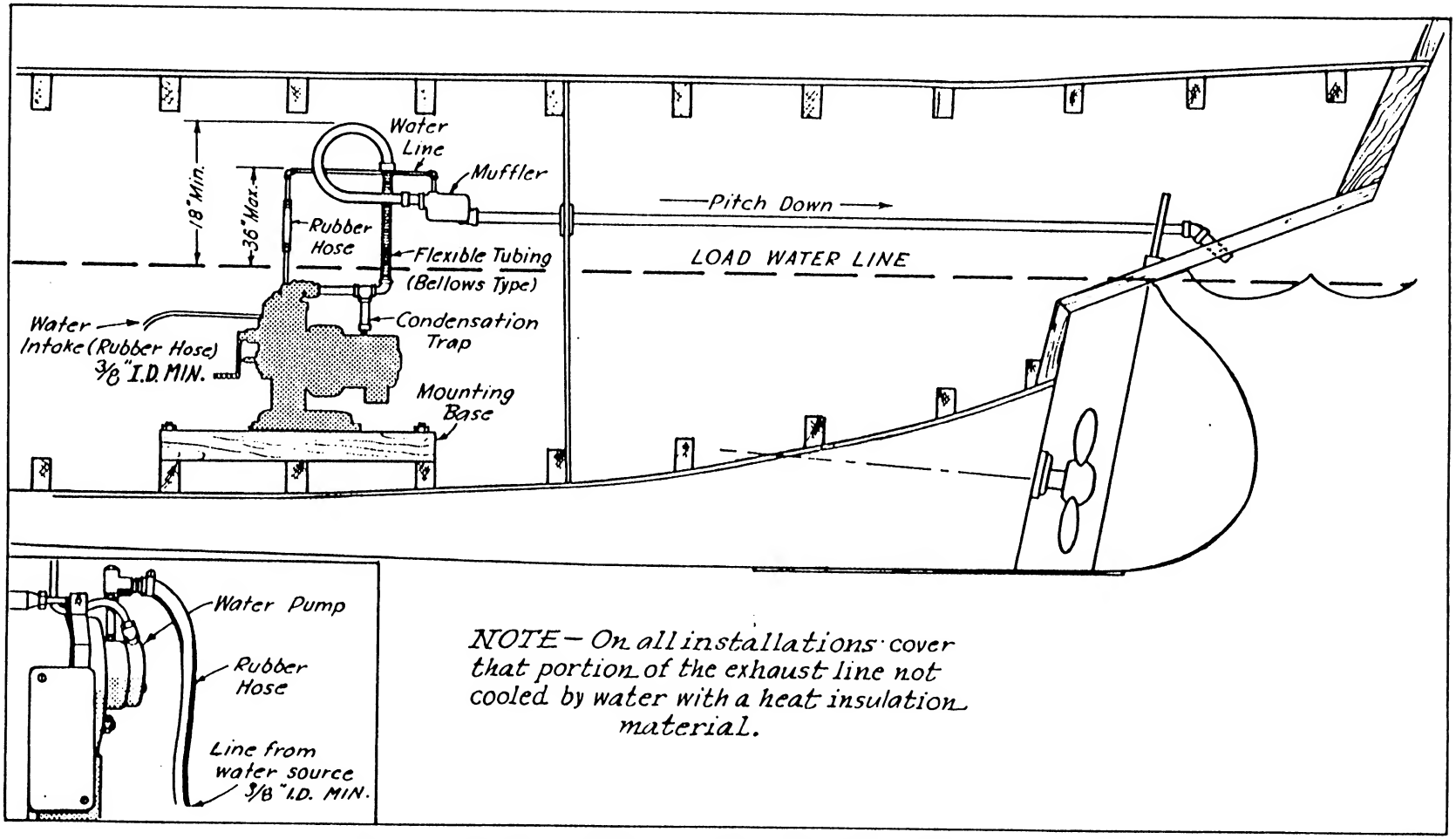


FIG. 3 - TYPICAL INSTALLATION - BELOW LOAD WATER LINE

Where the exhaust outlet is higher that the engine manifold, a condensation trap must be installed in the exhaust line as close to the engine manifold as possible. This applies even though no cooling water is introduced into the exhaust line. One of the products of combustion is H_2O (water) which must be kept from running back to the engine valves. This trap must be fitted with a valve or removable plug to permit draining the trap periodically.

A section of radiator hose at least 10 inches long should be placed in the exhaust line between the engine manifold, or condensation trap if used, and that portion of the exhaust system that is solidly mounted. It must be placed after the cooling water enters the exhaust system. This flexible section should be accessible at all times.

NOTE: When making an installation of the type shown in Fig. 3, an all metal constructed tubing should be used ahead of the point where cooling water enters the exhaust system. This type of tubing can be secured from Eclipse-Pioneer Co., Teterboro, New Jersey under part number HD1182.

The inlet and outlet to the muffler are offset from the center. The muffler must be installed in the exhaust line with the outlet at the bottom. This offset allows the muffler to drain itself of cooling water provided it is installed level or with the outlet end of the muffler lower than the inlet end. With the outlet end of the muffler down, the muffler may be mounted with a downward pitch of up to 60^{o}. In many installations the exhaust line cannot be made to slope gradually all the way to the outlet through the hull, the construction of the boat usually requiring a dip in the exhaust line which causes a low point. This will cause no trouble provided the rise in the exhaust line beyond the low point is not excessive. The muffler is provided with a drain connection on the bottom so that is may be installed at the low point, thus permitting the exhaust system to be drained to prevent freezing in cold weather. If the muffler is not installed at the low point in the exhaust line, install a drain plug in the line at this point.

If the generating plant is located well above the load water line and there is no possibility that the boat will list enough to ship water in to the exhaust pipe, the water-cooled muffler may be placed practically anywhere in the exahust line that is convenient, provided that the muffler is not installed closer than 8 inches from the nearest engine valve and is slightly below the outlet level of the exhaust manifold. Installations are equally successful with the muffler installed close to the engine or near the stern. The muffler should always have some tail pipe preferably not shorter than six pipe diameters for best results.

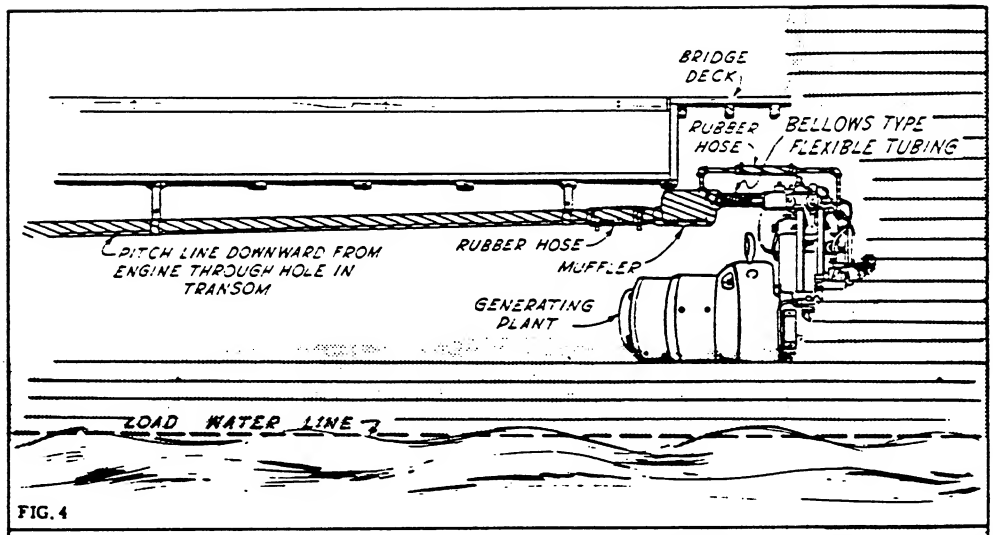


FIG. 4

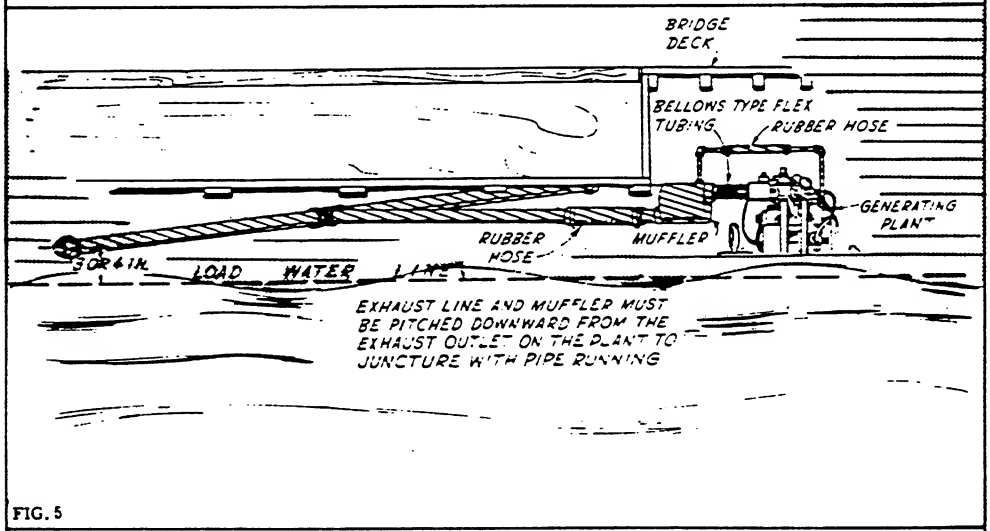
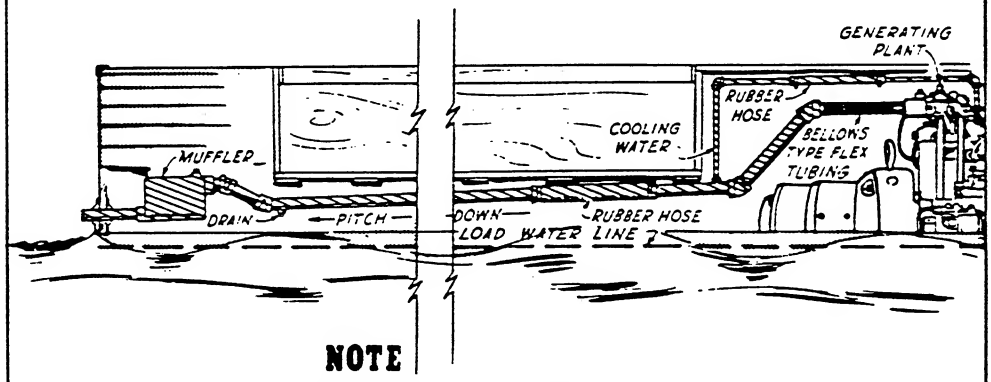


FIG. 5



NOTE

ON ALL INSTALLATIONS COVER THAT PORTION OF THE EXHAUST LINE NOT COOLED BY WATER WITH A HEAT INSULATING MATERIAL.

FIG. 6

TYPICAL INSTALLATION - ABOVE LOAD WATER LINE

The following methods of installation are suggested as they are representative of the ones most commonly used.

1. If the generating plant is installed below the load water line or there is a possibility of shipping water into the exhaust pipe, a vertical gooseneck loop should be placed in the exhaust line between the condensation trap and the flexible tubing. This loop should extend at least 18 inches above the highest possible water level. The loop and the flexible tubing should be covered with heat insulating material. The muffler and exhaust line from the muffler to the escape through the hull must be above the load water line and should slope gradually downward from the muffler to the outlet. The outlet must not be submerged. The muffler may be placed in the exhaust line anywhere that is convenient after the vertical loop. In this installation the cooling water is turned into the exhaust line immediately after the vertical loop, either through the muffler or through the exhaust line proper, whichever is most convenient. See Fig. 3.

2. The simplest installation of the generating plant and the watercooled muffler is made where the entire exhaust line can be made to slope gradually towards the point of outlet through the hull. The water discharge from the engine is piped into the top connection of the muffler which forms part of the trap for the water to protect the engine. See Fig. 4.

In similar installations it is sometimes necessary to place the muffler near the stern. With such an arrangement the water should be put into the exhaust line at the engine and the muffler placed in the exhaust line at the most convenient point.

3. If so desired, the muffler may be installed between the generating plant and an exhaust line to the sides of the vessel. The water in this case can be put into the muffler or into the exhaust line, whichever is most convenient. This type of installation is recommended for sailing vessels as the exhaust gases and cooling water will always escape properly regardless of which way the vessel heels. See Fig. 5.

4. The muffler can be installed in the stern due to space limitations. Here the water is put directly into the exhaust line immediately before the flexible hose and is then blown through the exhaust line. The low point in the exhaust line should have a drain plug for freezing protection. This installation forces the engine exhaust to raise the water the height of the rise in the exhaust line but if this rise does not exceed 1-1/2 feet, the back pressure will not be enough to perceptibly influence the engine. See Fig. 6.

WATER LINE CONNECTION. - The water pump is a gear driven, rubber impeller type pump. The maximum vertical lift for the pump under average conditions is five feet. The horizontal run at maximum lift should not exceed 20 feet. The suction opening of the water pump is equipped with a 1/8" pipe fitting. From this fitting attach a pipe nipple and 3/8" I.D. hose to the source of water supply. It is recommended that a strainer and a check valve be placed in the suction pipe at an accessible point as near to the thruhull fitting as possible to prevent foreign matter from entering the water pump and to maintain pump prime. The check valve should be installed adjacent to the strainer on the water pump side. The use of a strainer and a check valve is not necessary when a closed type cooling system is used.

With the exception of closed type cooling systems the entire water discharge from the engine should be through the exhaust line.

The water outlet from the cylinder head is 1/4" iron pipe size. The water inlet on the muffler is 3/8" iron pipe size. The connecting line must include a 10 inch or longer length of rubber hose to absorb plant vibration and facillitate engine thermostat service. If the pitch is upward from the plant, the line may be drained by the plug in the thermostat housing. The highest point in the water line from the engine thermostat should not exceed 3 feet above the thermostat to assure dependable lift by the pump.

A thermostat which opens at approximately 160°F. restricts the water flow through the engine. A by-pass within the thermostat housing casting is used in conjunction with the thermostat.

FRESH WATER COOLING. - Closed type cooling systems are commonly referred to as fresh water cooling and will be listed as such throughout this manual.

Fresh water cooling is recommended where the vessel is to be operated in freezing temperatures as it permits the use of antifreeze, thus eliminating the freezing hazard. A fresh water cooling system prevents salt water corrosion and eliminates sand and dirt deposits in the engine water jackets and pump. It will eliminate excessive pump wear and salt and mineral caking in the cylinder water jackets which lowers engine efficiency. A fresh water cooling system also serves to protect the cylinder head and block from the danger of cracking because of a sudden change in water temperature. Most accidents of this kind are caused by cold water rushing into the engine jackets when restarting the plant while the engine is still hot, resulting in a sudden contraction of the metal. It will be necessary to install a separate water pump to furnish cooling water for the exhaust line

when using a fresh water cooling system. This separate pump for sea water may be belt driven from the generating plant power take-off. A portion of the sea water must be returned through the plant exhaust system by properly restricting the sea water return line. An expansion tank must be used in the fresh water side of this system. Consult your marine dealer or the generating plant factory as to the type best suited for your installation.

In most installations where the vessels prime mover is equipped with a heat exchanger, it is possible to utilize this source of fresh water for cooling the generating plant as the additional heat placed on the main engines cooling system is very small. Heat exchangers and various types of fresh water cooling systems, suitable for use with these electric generating plants are commerically available.

Also available is a chemical process whereby both the fresh and salt water sides are protected from rust and mineral caking. Details concerning the Model A "Aqua-Clear" process may be obtained from Sudbury Laboratory, Box 487, South Sudbury, Massachusetts.

OPERATION IN FREEZING TEMPERATURES. - The entire cooling system must be drained as soon as the engine stops if the plant is operated during freezing temperatures, unless a fresh water system is used and protected with antifreeze. Even with a fresh water cooling system the water must be drained from the exhaust line.

FRESH WATER COOLING SYSTEM. - If a closed cooling system is used fill the system with clean alkali free water until the water in the expansion tank is at the level recommended by the manufacturer or supplier of the system. If the preparation is for below freezing temperatures, use an approved antifreeze in the proportion recommended by its manufacturer.

Do not change the water oftener than necessary to keep the cooling system clean or to change the anti-freeze. Allow a hot engine to cool before draining the cooling system.

FUEL TANK. - Where the vessel is powered by a Diesel engine, fuel may be taken from the main fuel tank to operate the electric generating plant. It is also permissible to install a separate fuel tank. With either fuel source, comply with the applicable marine code.

Wherever practicable the fuel supply should be located below the level of the plant fuel inlet. This installation will permit the use of a fuel line with no shut-off valve. A fuel line with no shut-off valve is much more satisfactory from a standpoint of trouble free engine performance due to the possibility of air being sucked into the system by the fuel transfer pump. With this installation, the top of the fuel tank must be at least 6 inches below the fuel transfer pump inlet to prevent siphoning of fuel when servicing the fuel filter. Also the bottom of the tank must be within 6 feet below the fuel transfer pump inlet to assure dependable distance of fuel lift.

Wherever the fuel supply must be above the plant fuel inlet, a shut-off valve must be provided to prevent siphoning of fuel when servicing the plant fuel filter. Install the valve to close against the flow. Locate the valve preferably below the level of the bottom of the tank and near the generating plant. This location of the valve will facillitate bleeding the air from the line.

If a separate fuel tank is installed, the tank should be located in a water-tight compartment separate from but adjacent to the generator compartment. It should be accessible for exterior examination and mounted above the load water line in a pan or on a metal lined, water-tight flat with overboard drains. Such pan or flat is not recommended where the bottom of the fuel tank is below the load water line. Where this arrangement is not practicable, the fuel tank may be located to suit the design of the vessel but preferably just outside of the engine compartment to avoid the use of excessive lengths of fuel pipe. The tank should be substantially secured in position to prevent movement and installed to afford easy external examination and accessibility for servicing. Portable tanks should not be used below decks.

It is recemmended that all outlets pass through the top of the tank. Fill pipes and sounding holes shall be so arranged that vapors or possible overflow when filling cannot escape to the inside of the boat. A pipe made tight to the tank and to a filling plate on the deck outside of the cockpit of coamings meets these requirements.

Fill pipes should extend nearly to the bottom of the tank and a strainer of non-corrodible wire mesh fitted into the throat of the fill pipe. Vents or reliefs leading outboard shall be provided on all fuel tanks. On vessels liable to heel, two vents shall be led to starboard and two to port.

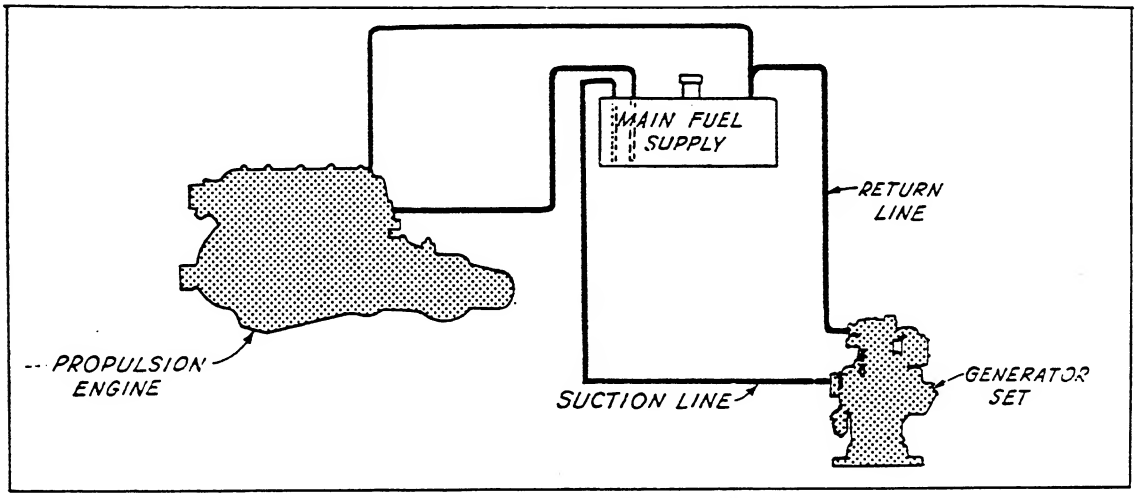


FIG. 7 - FUEL SYSTEM

FUEL LINES. - Fuel lines shall be of seamless drawn annealed copper tubing or iron pipe of copper tubing size. They shall be run in sight whenever practicable, protected from mechanical injury and effectively secured against vibration by neat fittings, soft metal lined or non ferrous metal clips with no sharp edges in contact with the tubing. Where passing through steel decks or bulkheads, lines shall be protected by close fitting ferrules of non-abrasive material. The fuel inlet on the fuel filter requires a 1/8" iron pipe size fitting .

The installation of flexible fuel lines between the plant and the two solid lines for fuel supply and return drip is recommended. If a flexible fuel line is not used, make one or more loops in the solid line near the plant to absorb vibration. The loops should be made so that the lines will drain when disconnected.

The suction line runs from the outlet on the fuel tank to the fitting on the primary filter. The return fuel line runs f rom the fitting on the injection nozzle to the top of the fuel tank. Make sure all connections are tight without applying too much pressure on the fitting. On the suction side of the fuel system use Permatex or an equivalent pipe thread compound on all connections having a pipe thread. USE EXTREME CARE THAT NONE ENTERS THE SYTEM. Don't use compound on connectors or flared fittings. An air leak at any point in the suction side of the fuel system will cause hard starting and inefficient operation.

Installing the suction line inlet slightly above the bottom of the main tank will help avoid sucking moisture and sediment into the fuel line. However the fuel supply level must be maintained to avoid air being sucked into the line.

WIRING. - All wiring shall be run as high as practicable above the accommodation flooring. Surface wiring shall be protected. However, the extended use of conduit or metallic tubing is not recommended because of the possibility of moisture accumulating therein.

Concealed wiring may be unprotected but shall be secured by neat fitting, non-ferrous cleats with rounded edges spaced not more than 14" apart.

Lead sheathed, unarmored conductors and conductors armored with spiral wound flat metal stripping are not approved. Conductors armored with metallic basket weave or helical wire, with or without lead sheathing, may be used.

Wiring joints and splices shall be mechanically secure. Unless a splice is made by a solderless wire connector, it shall be thoroughly soldered. Where ends of stranded conductors are to be clamped under terminal screws, they shall be formed and soldered unless fitted with solderless lugs.

Splices, unless provided with insulated wire connectors, shall be first taped with rubber tape, then with friction tape to afford insulation equivalent to that of the conductors joined.

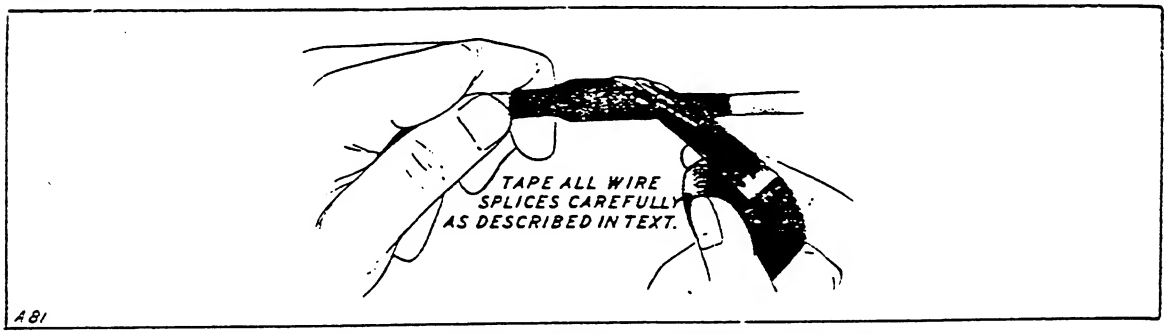


FIG. 8 - TAPING WIRE CONNECTIONS

Protect each branch circuit of the system with a fuse of the proper amperage accordingly to the carrying capacity of the wire in the circuit regardless of the total load that may be connected to the circuit. Such fuses are in addition to the main fuse that protects the entire system.

Accessories such as switches, fuses and sockets shall be standard National Electrical Code types for the loads to be carried.

Lighting and power switches and light fixtures in the engine room, forepeak and galley (if gas is used for the range) shall be of the explosion proof type. The use of explosion proof switches throughout the under deck is recommended.

The wire size will depend largely on the distance and permissible voltage drop between the plant and the load and the amount and kind of load. Consult a competent electrician. Check national and local codes before installing. Install a circuit breaker or a fused main switch in the load circuit near the plant.

WIRING TABLE

Table of Wire Sizes for 32 Volt - 2% (.64) Voltage Drop

WIRE SIZE NO.		12	10	8	6	4	2	0	
WATTS	AMPS	*Distances expressed in feet per wire size.							
50	1.56	120	200	320	490	800	1200		
100	3.13	60	100	160	245	400	600		
150	4.69	40	70	110	165	260	400		
200	6.25	30	50	80	125	200	300		
250	7.81	25	40	65	100	160	240		
300	9.38	20	35	55	80	130	200		
400	12.50	15	25	40	60	100	150		
500	15.63	12	20	30	50	80	120		
600	18.75	10	15	25	40	65	100		
800	25.00	--	12	20	30	50	75		
1000	31.25	--	10	15	25	40	60		
1200	37.50	--	--	12	20	30	50		
1400	43.85	--	--	10	15	25	45		
1500	46.88	--	--	--	10	20	40		
2500	78.13	--	--	--	--	15	25	40	
3500	109.39	--	--	--	--	10	15	25	

* Above figures represent a point to point distance for a 2 wire run.

If 4% voltage drop is permissible, double the distances listed.
If only 1% voltage drop is allowable, divide the distances by 2.

WIRING TABLE - 115 V.

Unity Power Factor. 2% Voltage Drop (2.3 Volts)

WIRE SIZE NO.		14	12	10	8	6	4	2
WATTS	AMPS	* Distances expressed in feet per wire size.						
100	.87	510	810	1280	2040	3250	5300	8200
200	1.74	255	405	640	1020	1625	2650	4100
300	2.61	170	270	430	680	1080	1770	2730
400	3.48	125	200	320	510	810	1325	2050
500	4.35	100	160	255	410	650	1060	1640
750	6.52	65	100	170	275	430	710	1090
1000	8.69	50	80	125	205	325	530	820
1500	13.04	35	55	85	140	215	350	550
2000	17.38	25	40	65	100	160	265	410
2500	21.73	20	35	50	80	130	210	350

* Above figures represent a point to point distance for a 2 wire run. If a 4% voltage drop is permissible, double the distance listed. If only 1% voltage drop is allowable, divide the distances listed by 2.

Single Phase 115 Volt A.C. - Use 115 Volt table above.

Single Phase 115/230 Volt A. C. 3 Wire - Use 115 Volt table above for each 115 Volt Circuit.

Single Phase 230 Volt A. C. - Double the distances listed in the 115 Volt table above. Use Amps Column.

CONNECTING THE LOAD (AC Plants). - Comply with the above instructions under WIRING and select the following instructions applicable to the type of plant.

1 PHASE, 2 WIRE PLANT. - Two leads extend out from the plant just below the generator end bell. These are the main generator leads. Each lead has a terminal. It is advisable to install like terminals on the leads from the fused switch or circuit breaker so that a good solid connection can be made by bolting the leads together. The leads may also be connected by using solderless connectors if the terminals on the generator leads are removed.

The generator leads are marked "M1" and "M2". The lead marked "M1" is the hot lead and is to be connected to the "hot" side of the fused switch or circuit breaker. The lead marked "M2" is the "grounded" lead and is to be connected to the grounded side of the fused switch or circuit breaker. The main line wires are then connected to terminals in the fused switch or circuit breaker. Be sure to connect the hot side of the main line to the hot side of the switch.

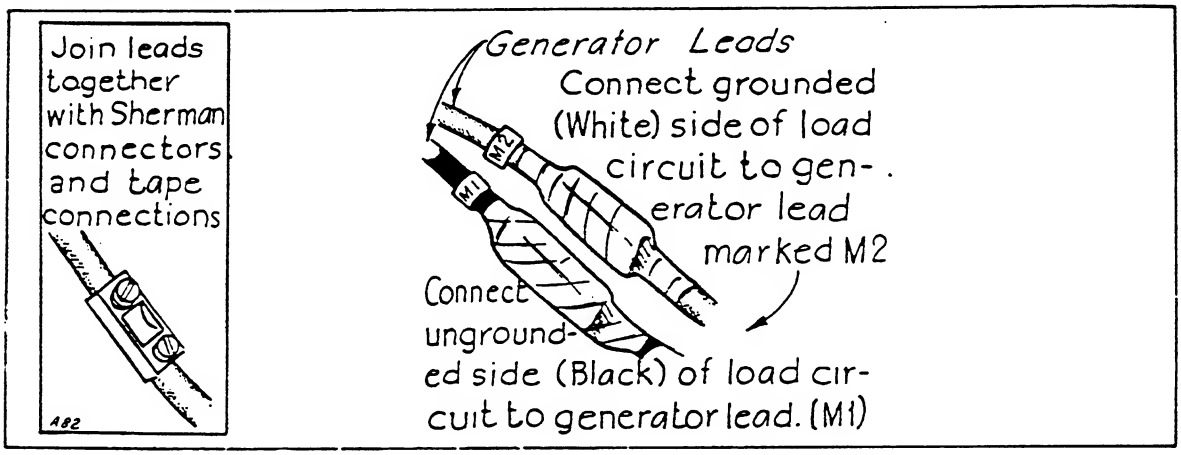


FIG. 9 - 1 PHASE, 2 WIRE LOAD CONNECTIONS

1 PHASE - 3 WIRE PLANTS. - The method of connecting leads together is the same as given for 1 phase, 2 wire plants. However, these plants have three wires coming out from the plant marked "M1", "M2" and "M3". Both 115 volt current and 230 volt current are obtainable. The lead marked "M2" is grounded and is to be connected to the grounded terminal of the fused switch or circuit breaker. The leads marked "M1" and "M3" are hot and are to be connected to the other two terminals on the plant side of the fused switch or circuit breaker, one lead to each terminal.

Two 115 volt circuits are available. One circuit across "M1" and "M2" and another circuit across "M2" and "M3". The load on each 115 volt circuit should not be more than 1/2 the capacity of the plant.

One 230 volt circuit is available. This circuit is across "M1" and "M3". "M2" is not used with a 230 volt circuit. If only 230 volt current is used, the full rated capacity of the plant may be used.

Both 115 volt current and 230 volt current may be used at the same time. However, the total of either 115 volt load plus 1/2 the 230 volt load should not exceed 1/2 the capacity of the plant. For example: a total of 1500 watts is available on each 115 volt circuit of a 3000 watt single phase 3 wire plant. If 1000 watts of current is used on each 115 volt circuit, only 1000 watts of 230 volt current can be used at the same time. If 2000 watts of 230 volt current is used, only 500 watts of 115 volt current is available on each 115 volt circuit.

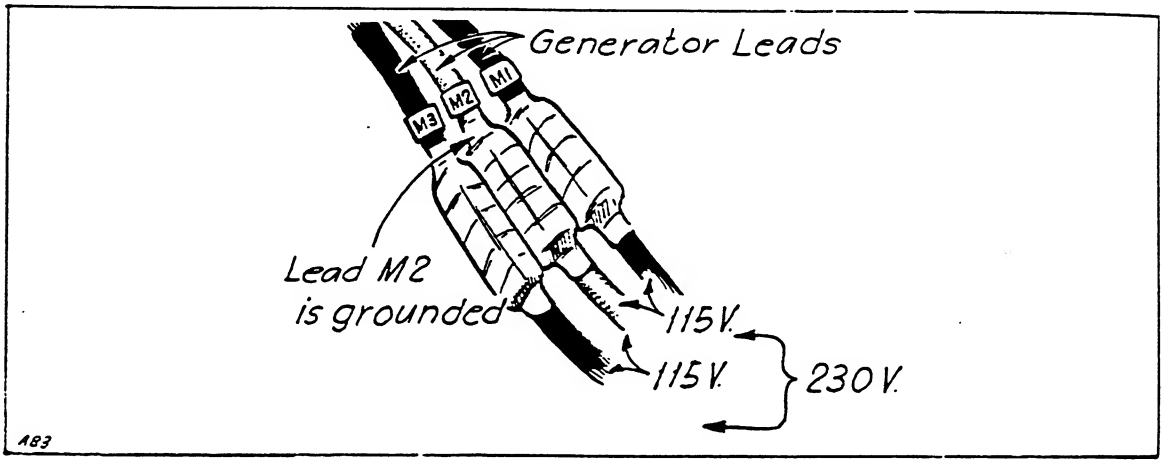


FIG. 10 - 1 PHASE, 3 WIRE LOAD CONNECTIONS

115 VOLT AC - 32 VOLT DC PLANTS (Dual Purpose). - For connecting the 115 volt ac load, refer to the instructions as given for the single phase, two wire plant.

For connecting the 32 volt dc load, refer to the instructions as given for the 32 volt Battery Charging Plants.

For connecting the battery, refer to the instructions "CONNECTING THE BATTERY (Dual Purpose Plants)".

CAUTION: Remember that a total of up to 750 watts of direct current and 2250 watts of alternating current may be used at the same time or divided in any proportion within the rated output limits of the generator. Maximum dc output should not exceed 750 watts. Total current available is 3000 watts. If only alternating current is used, 3,000 watts is available. When direct current is used, subtract the amount of direct current used from the total generator capacity to find the amount of alternating current available. For example: If 500 watts of dc is used, only 2500 watts of ac is available.

CONNECTING THE LOAD (Battery Charging Plants). - The main line load circuit should be connected to the batteries through a fused switch or circuit breaker. The lead wires from the battery fuse block to the main line fuse block should be of sufficient size to carry the full rated capacity of the generator plus the full rated capacity of the battery. Branch circuits from the main circuit should be properly fused. Smaller wire may be used for these branch circuits but the wire should be large enough to carry the amperage of the load on each circuit.

Make connections from the main line switch to the fused battery switch. Connect leads to the terminals on the battery side of both switches. Observe the same polarity used in connecting the battery. See Fig. 11.

CONNECTING THE BATTERY (32 Volt Battery Charging Plants). - The 24 or 32 volt battery charging plant has an UNGROUNDED system. In this system, all electrical components of the plant (except the glow plug which is used only during starting) are electrically insulated from the engine and control box. Therefore, with this system it is not essential whether or not the generating plant polarity agrees with the polarity of other electrical equipment aboard in regard to damaging electrolysis (chemical)action.

NOTE: The ungrounded system may be converted to a grounded system by connecting a ground to the panel terminal (or load) to which generator lead A2 is connected. (Connecting to the opposite side will blow the fuse). Then the battery polarity may be reversed (battery positive connected to plant negative terminal and battery negative connected to plant positive terminal) provided the next start is made by the start switch (rather than by manual cranking) to correct the generator polarity. Battery polarity of a grounded plant must agree with polarity of other electrical equipment aboard (on marine installations only) to avoid severe electrolysis (chemical) action causing damage to propellors, sea cocks, etc., which contact salt water, while the plant is running.

Ammeter readings on these units will be correct only with a negative ground. With a positive ground the ammeter readings will be reversed. This can be remedied by reversing the wires connected to the ammeter terminals. THE AMMETER WIRES MAY BE REVERSED ON ALL BATTERY CHARGING UNITS IF THE UNIT IS POSITIVE GROUNDED.

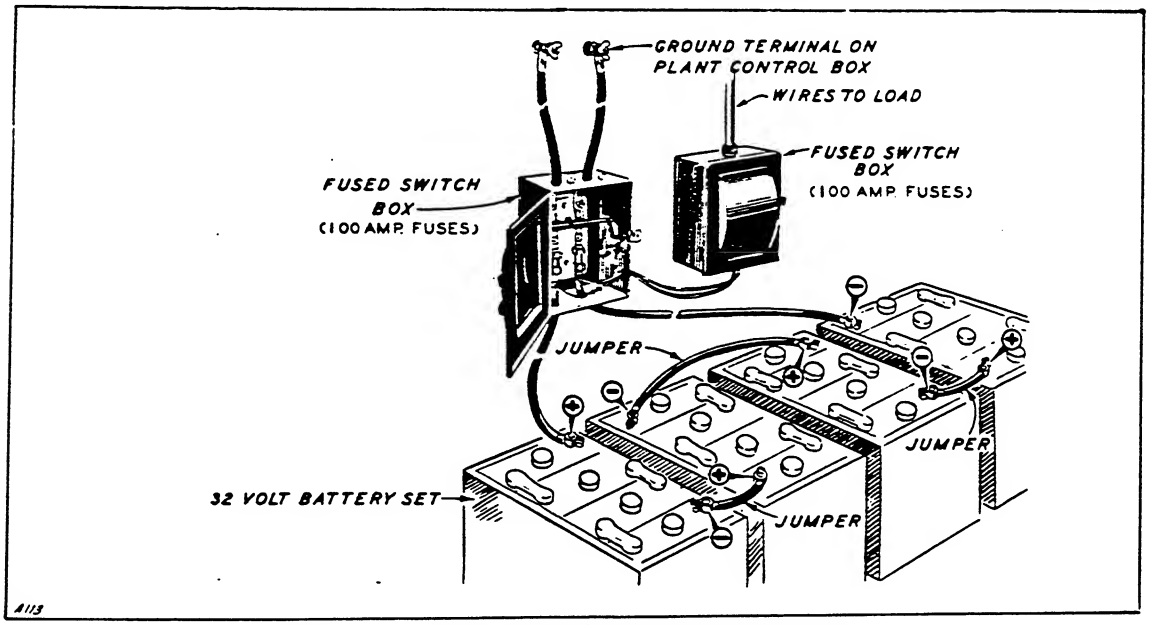


FIG. 11 - BATTERY CONNECTIONS - FOR BATTERY CHARGING PLANTS AND DUAL PURPOSE PLANTS

Battery cables and batteries are not supplied with battery charging units. However these are readily available from your local marine dealer.

Prepare the batteries for operation and install them according to the battery manufacturers instructions.

A fused switch should be installed between the plant and the batteries as shown in Fig. 11. Run cable from the battery to the switch and then from the switch to the plant control panel.

For a positive grounding of the battery, connect one cable from the positive (+) post on the battery to the grounded side of the fused switch. Connect a second cable from the grounded side of the fused switch to the terminal marked GROUND on the plant control panel. Make connections from the negative (–) post on the battery to the ungrounded side of the switch and to the remaining terminal on the plant control panel, using cables of equal size and length to those used for the positive cable connections.

CAUTION: Connections may be reversed at the ammeter terminals when using a positive ground.

For a negative grounding of the battery, connect one cable from the negative (–) post on the battery to the grounded side of the fused switch. Connect a second cable from the grounded side of the fused switch to the terminal marked GROUND on the plant control panel. Make connections from the positive (+) post on the battery to the ungrounded side of the switch and to the remaining terminal on the plant control panel, using cables of equal size and length to those used for negative cable connections.

CAUTION: This applies to all plants, ac or dc. Do not hand crank your unit on the initial run after completing the installation without first pressing the START button. It is this cranking current that excites the generator field in the proper direction for the polarity that you have used. After the initial run the generator will maintain this polarity and the unit may be hand cranked if so desired.

It is advisable to connect the ground last when connecting a battery and to disconnect the ground first when disconnecting a battery.

CONNECTING THE BATTERY (Dual Purpose Plants). - A grounded system is used. These plants are designed to operate with either a negative or a positive grounding of the battery without regard to polarity. However, unless the generator is properly grounded with respect to other electrical equipment aboard, severe electrolysis (chemical) action will be set up when the unit is running. This will cause damage to propellors, sea cocks and other fittings which contact salt water.

Ammeter readings on these units will be correct only with a negative ground. With a positive ground the ammeter readings will be reversed. This can be remedied by reversing the wires connected to the ammeter terminals.

Battery connections incorporating a fused switch box should be as described and illustrated for the 32 volt battery charging plants. Refer to those instructions.

CONNECTING THE BATTERY (A.C. Plants). - A grounded system is used. These plants are designed to operate with either a negative or a positive grounding of the battery without regard to polarity. However, unless the generator is properly grounded with respect to other electrical equipment aboard, severe electrolysis (chemical) action will be set up when the unit is running. This will cause damage to propellors, sea cocks and other fittings which contact salt water.

Ammeter readings on these units will be correct only with a negative ground. With a positive ground the ammeter readings will be reserved. This can be remedied by reversing the wires connected to the ammeter terminals.

"Wet" starting batteries are sometimes supplied with the plant. These batteries are in a well charged condition when shipped from the factory. However, if they are not placed in service within 30 to 40 days, they may have become partly discharged. If such is the case, they should be given a freshening charge before being placed in service. If "dry" batteries are supplied, they must be prepared for use according to the instructions given on the tag attached to the batteries.

Batteries should always be installed on a wooden or metal rack to afford a free circulation of air around the battery.

Cables for making connections between the plant and the battery are supplied with all remote start plants even though the starting batteries are not. The short jumper cable connects the two 6 volt batteries in series to form a 12 volt battery. The two longer cables connect the battery to the plant. These two long cables are the same size and length.

When making cable connections at the battery, it may be necessary to spread the cable lug open slightly before it will fit properly on the terminal post. Don't use a hammer to drive the cable lugs onto the battery terminal posts, the battery may be damaged. The cable lugs should have full contact on the battery terminal posts to prevent loss of current at this point. Be sure the contact surfaces of the cable lugs and battery terminal posts are clean before making connections. Coat the lugs and battery terminal posts with a thin coating of vaseline to help in preventing corrosion from forming.

Make battery connections as follows:

If a single 12 volt battery is used for the plant, connect one of the long battery cables from the positive (+) post on the battery to the POSITIVE terminal on the plant control box. Connect the other long cable from the negative (−) post on the battery to the NEGATIVE terminal on the plant control box. The short jumper cable is not used with a single 12 volt battery. Be sure connections are tight at all points.

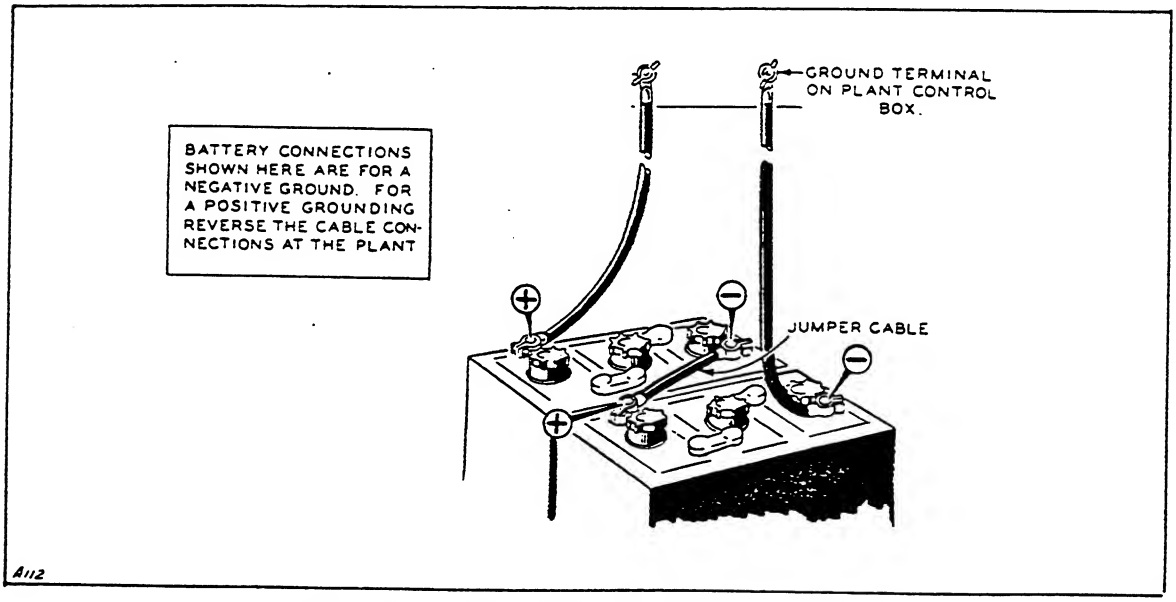


FIG. 12 - BATTERY CONNECTIONS - FOR ALTERNATING CURRENT PLANTS

If two 6 volt batteries are to be connected in series to form a 12 volt battery, connect the short jumper cable from the negative (—) post of one battery to the positive (+) post of the other battery. Then make the longer cable connections as described in the above paragraph.

CONNECTING REMOTE START-STOP STATIONS. - One or more remote control start-stop stations may be installed at various points. The wire length from the plant to the switch determines the wire size necessary. Comply with this chart:

WIRE SIZE NECESSARY	MAXIMUM PERMISSIBLE WIRE LENGTH (In Feet)			
	3MDSP-1R, 3MDSP-3R	3MDSP-1R4	3MDSP-232R	205MDSP-224R
#18	85	140	200	130
#16	135	240	335	220
#14	215	360	500	350
#12	350	575	800	550

Refer to Fig. 13. Note that there is a terminal block marked "REMOTE CONTROL", B+, 1, 2, and 3. Terminal number 1 is used as a common ground, terminal number 2 connects to the stopping circuit of the plant and terminal number 3 connects to the starting circuit of the plant. The terminal marked B + is to be used only with an automatic control installation.

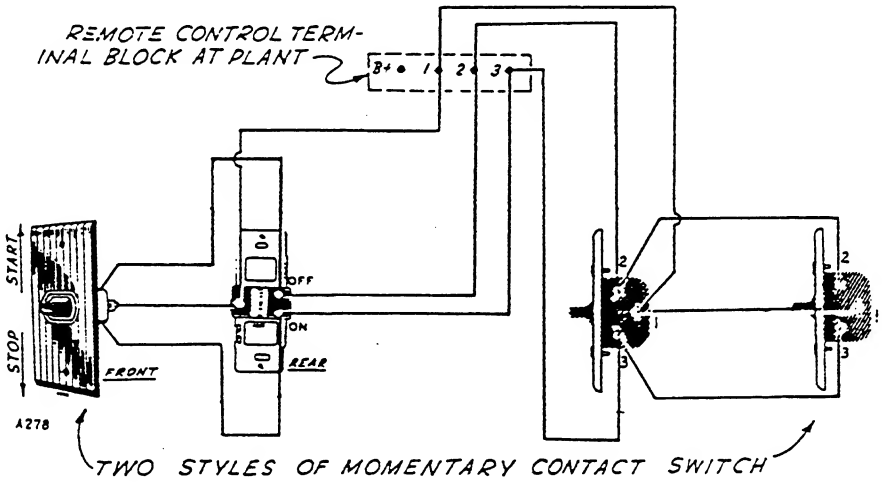


FIG. 13 - REMOTE START STOP STATIONS

Connections for two styles of momentary contact toggle switches for use as Remote Start-Stop Stations are illustrated. Connect all number "2" or "OFF" switch terminals to the number "2" terminal on the plant terminal block. Likewise, connect together all number "3" or "ON" terminals and also, all number "1" or "single" (not marked) terminals. If the switch is to mounted vertically, start position should be upward to conform with operation at the plant when a toggle switch is used.

AUXILIARY LIGHTING CIRCUIT (Alternating Current Plants). - An auxiliary lighting circuit may be connected to the starting battery if so desired. This auxiliary circuit will provide for a night light, trouble or service light. The maximum load on this circuit should not exceed 150 watts at any time. Lights, fixtures, connectors, and wire should conform to those needed for a 12-volt dc circuit. Make connections directly at the battery.

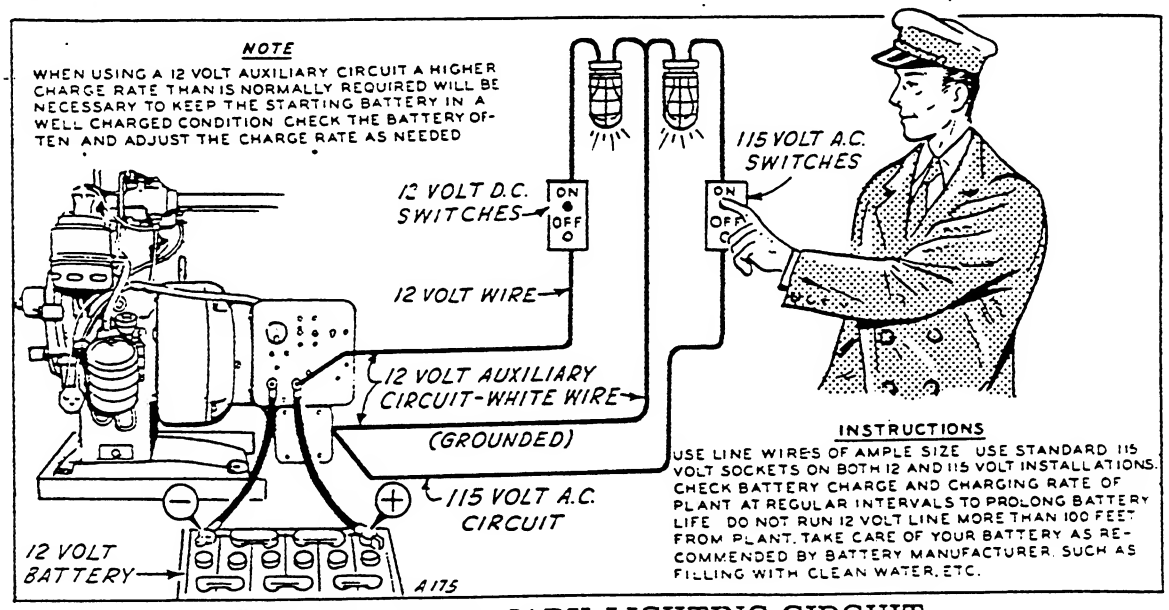


FIG. 14 - AUXILIARY LIGHTING CIRCUIT - FOR ALTERNATING CURRENT PLANTS

WATER PUMP. - The water pump is an impeller type and usually it will prime itself and hold its prime. The condition of the pump and the required lift from the water source will determine the necessity for priming. The water pump should be primed before starting a new engine or whenever the cooling system has been drained. To prime the pump, remove the plug in the pump inlet fitting and add water while cranking the engine.

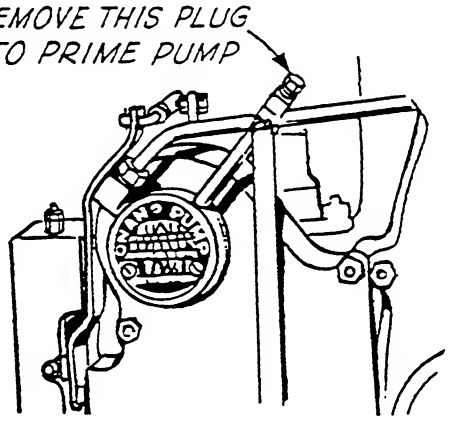
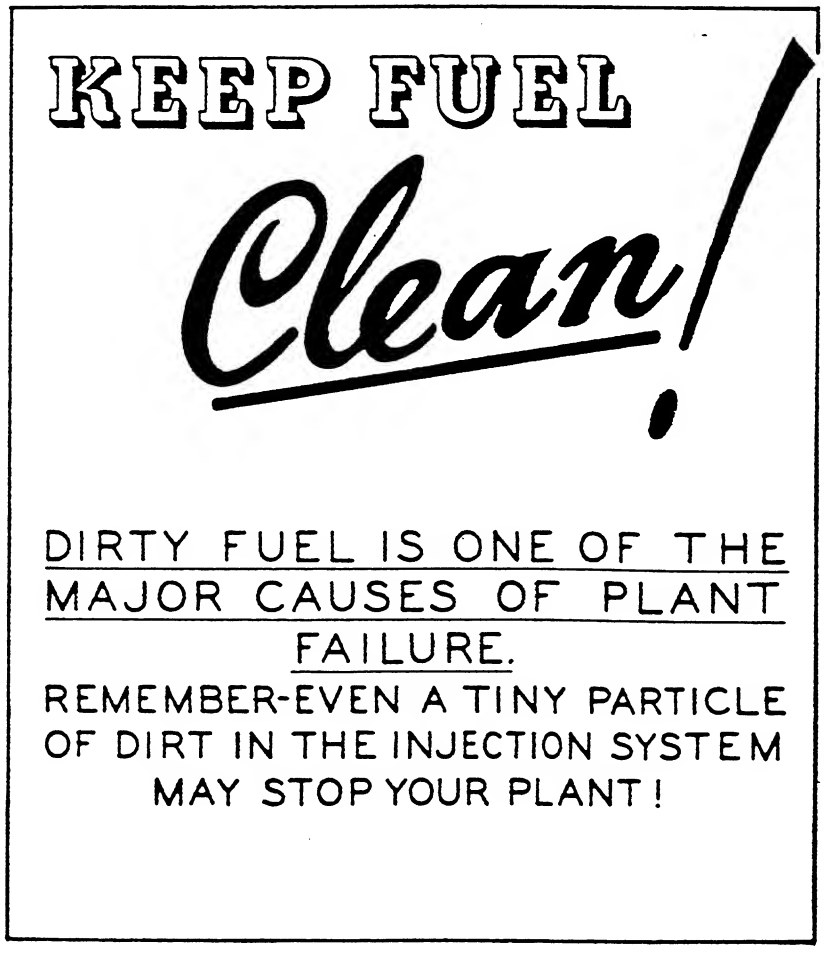


FIG. 14 A - PRIMING THE WATER PUMP

CHECKING NEUTRAL BRUSH RIG POSITION . - Witness marks show the neutral brush rig position as adjusted at the factory. Details are given in the Maintenance and Repair Section of the manual. Check the brush rig position and see that all generator brushes are in place in their guides.

RECHECK. - Carefully recheck all instructions to see that nothing has been left undone. Then supply the engine with proper oil and fuel as described under Preparation, Operation, and Periodic Service in the manual.

Bleed the air from the fuel system as instructed under Preparation in the manual.



RECOMMENDED FUEL. - No. 2 Furnace Oil. Premium Diesel fuels not required.

Alternates - - - - - - No. 1 furnace oil (distillate and range oil) and kerosene may be used but one quart (U.S. Measure) of SAE No. 30 lubricating oil should be added to each 25 gallons of such fuel to provide lubrication for fuel injection equipment.

SPECIFICATIONS. - (Specifications may be changed without notice).

GRAVITY (Minimum) A.P.I. - - - - - - - - - - - -	30
VISCOSITY (Saybolt Universal at 100 °F) - - - -	30.5 to 45 Seconds
CETANE NUMBER - - - - - - - - - - - - - - - - - -	43 Min.
SULPHUR (by weight) - - - - - - - - - - - - - - -	1.0% Max.
CONRADSON CARBON (10% Bottoms) - - - - - -	0.15% Max.
FLASH POINT - - - - - - - - -	130°F. Minimum or legal Minimum
WATER AND SEDIMENT (by volume) - - - - - - -	None
POUR POINT - -	Must be 10° lower than minimum temperature at which fuel oil is to be used.

Use fuel with low sulphur content to minimize ring sticking and bearing corrosion. Keep fuel supplies in clean containers and adequately protected from rain, snow and dirt. KEEP THE FUEL SYSTEM CLEAN. If removal of any part becomes necessary, wrap it in clean paper, never in cloth or waste. Use clean diesel fuel for cleaning parts.

RECOMMENDED OIL. - Use detergent lubricating oils classified by the American Petroleum Institute as Service "DG", or, as marketed by most manufacturers, "MS/DG". If sulphur content of fuel is higher than recommended maximum, use Service "DS" lubricating oil (or series III, having more detergent and other additives).

Use SAE No. 30 grade (viscosity) oil in the crankcase, and air cleaner, as instructed under PERIODIC SERVICE. Multiviscosity oils, as 5W-20 or 10W-30, are not recommended, especially at higher temperatures, as the oil consumption increases greatly. At low temperature where cold starting may be difficult and high oil consumption is not a factor, the use of multiviscosity oil may be justified.

OIL CAPACITIES. - Crankcase - 4 quarts (U.S. Measure) excluding filter. Approximately 5 quarts with new filter cartridge.

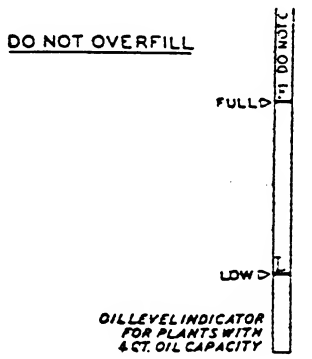


FIG. 15 - OIL LEVEL

PREPARATION FOR STARTING. - (1) Fill the fuel tank with clean fuel.

(2) Fill the crankcase with 4 quarts (U.S. Measure) of the recommended viscosity and service grade of lubricating oil. This excludes oil for the filter. If the preparation is for cold temperature operation, do not put the oil into the crankcase until just before starting.

NOTE: SAE No. 10 oil may be used at temperatures below 40°F. See Cold Temperatures under the heading ABNORMAL OPERATING CONDITIONS.

CAUTION: BE SURE TO REPLACE OIL FILL CAP SECURELY OR AIR LEAKAGE AT THIS POINT MAY REDUCE CRANKCASE VACUUM, RESULTING IN OIL LEAKAGE AT THE OIL SEALS.

(3) The air cleaner (silencer) is the dry type. Before the initial start, especially under dirty operating conditions, squirt a limited amount of oil not heavier than SAE No. 10 on the pack of the air cleaner. Allow it to drain.

(4) Open the air inlet and air outlet ventilators except as necessary to control the air flow for cold temperature operation.

(5) See that the main line switch or circuit breaker is in the OFF position.

(6) Place a drop of SAE No. 30 oil on the joints of the governor linkage.

(7) Open the fuel shut-off valve at the fuel tank.

(8) Loosen the injection pump bleeder plug. This plug is located just above the throttle arm. See Fig.16. Then work the primer lever on the fuel pump until fuel flows freely at the plug opening and there are no air or foregin gas bubbles in evidence. Either tighten the plug now, or leave it "cracked" during the first minutes of operation to allow the escape of a trickle of fuel as well as additional air and gasses. Another bleed plug is located at the top of the secondary fuel filter. Bleeding by this plug extracts any air-trapped in the secondary filter cover and should be done in conjunction with the regular method at the injection pump. Tighten this plug before completing the bleeding at the injection pump.

NOTE: If the cam is on the high side the pump will not operate. Turn the crankshaft over one complete revolution to correct. Leave the primer lever at the "in" position when through priming the fuel system. The pump will not operate with the lever at the "out" position.

The above procedure should be followed when starting a new engine, an engine that has been idle for a long period of time, or an engine that has run out of fuel.

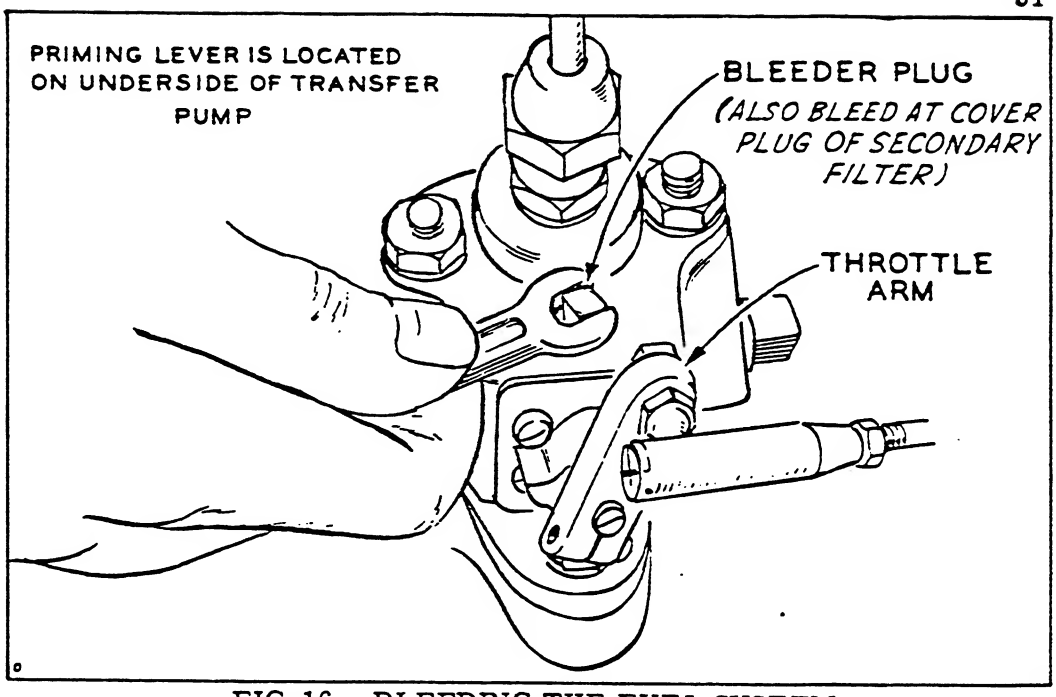


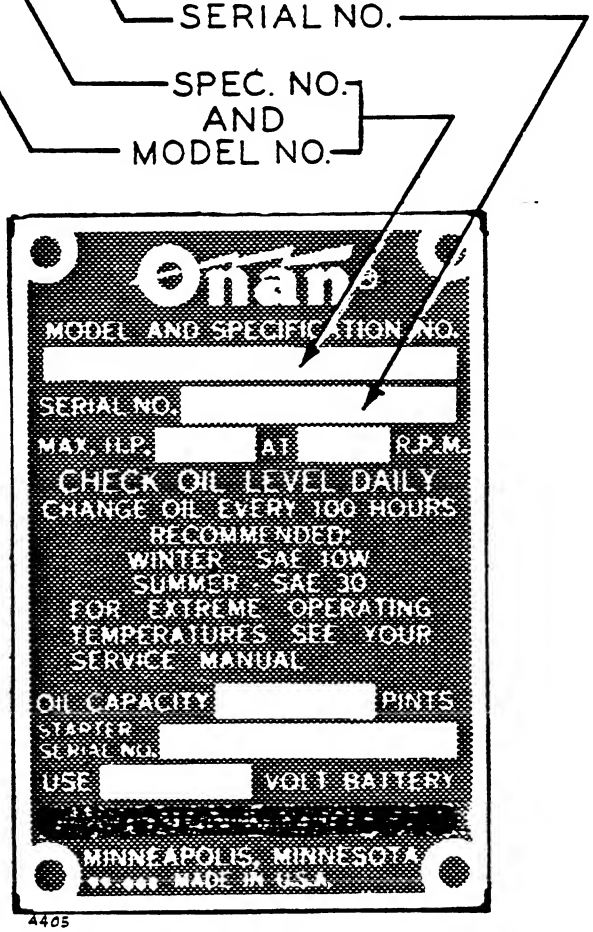
FIG. 16 - BLEEDING THE FUEL SYSTEM

The flow of fuel is from the fuel tank to the primary fuel filter, to the transfer pump, to the secondary fuel filter, to the injection pump, to the injector nozzle and to the combustion chamber. Fuel used to lubricate the nozzle pintle, returns to the fuel supply tank through the return line.

Important !

Always GIVE THESE NUMBERS WHEN ORDERING REPAIR PARTS OR REQUESTING SERVICE INFORMATION FOR YOUR UNIT !

WRITE IN NUMBERS SHOWN ON UNIT NAMEPLATE



STARTING THE PLANT

The following instructions apply to starting the plant in temperatures of 50°F. and above. When starting a plant at temperatures below 50°F., turn to the section on ABNORMAL CONDITIONS for further instructions.

Check the entire installation to see that all connections and preparations have been made. If the preparation has been made for cold temperature operation, be sure the crankcase is filled with proper oil.

The engine will have a sharp knock as it fires until it has warmed up. This is a normal condition.

STARTING ELECTRICALLY. - (a) Decompression release mechanism operates electrically. However, if its plunger was manually lock IN, disengage its pin from the locking notch. (b) Depress glow plug heater switch and hold for one minute; this applies only when the operator is at the plant. (c) Depress the START switch to crank electrically. The glow plug heats automatically during cranking electrically. (d) When the engine is turning over fast enough to build up lubricating oil pressure, then the decompression release will operate. (e) Continue to press the start switch until the engine comes up to speed. (NOTE: If false starts indicate more time is needed to gain sufficient cranking speed before compression takes place, temporarily disconnect the wire to the solenoid and operate the plunger manually for an emergency start.)

STARTING MANUALLY. - Manual cranking is strictly for emergency in the event of a discharged battery. The principle is to spin the flywheel fast enough so that its momentum will carry past the compression stroke after the decompression release plunger is pushed IN. Someone to assist the operator will be of help.

(a) Decompression release plunger should be in OUT position. (b) Work the priming lever on the transfer pump a few times to assure adequate fuel. CAUTION: Leave this lever inward so that the normal pump action is not restricted. (c) Depress the glow plug heater switch and hold it for one minute before cranking and continue to hold it during and after cranking until the engine comes up to speed. (d) Engage the hand crank and crank the engine. (e) When at top cranking speed, push the decompression release plunger to IN position and either hold it there or temporarily lock it until generator voltage builds up enough to energize the solenoid. (f) Check the lubricating oil pressure immediately. (g) Do not operate the plant unless the battery is connected.

The hand cranking sprocket wheel is a chain drive with the crankshaft sprocket wheel. The engine crankshaft rotates two revolutions or one compression stroke for each turn of the hand crank. The four jaws of the hand crank permits the operator to engage the crank for best advantage in regard to the compression stroke. To assure quick release, lightly lubricate the hand crank or the crank engaging shaft. Cranking at good speed before allowing compression should prevent serious kick-back at the hand crank. Always keep the hand crank accessible.

If desired, the hand crank may be used with care at the same time as cranking is attempted electrically. In this case the controls will operate electrically.

STARTING WITH PRIMER ATTACHMENT. - For engines using a starting fluid primer, start as follows: Insert cartridge (or capsule) in puncturing tool; puncture capsule; hole glow plug switch one minute; prime with two shots of fluid before engine is cranked; continue to prime to keep engine firing; use up entire capsule of starting fluid. If poor cranking is due to insufficient battery amperage, use additional batteries connected in parallel. This may be necessary at temperatures under 15°F.

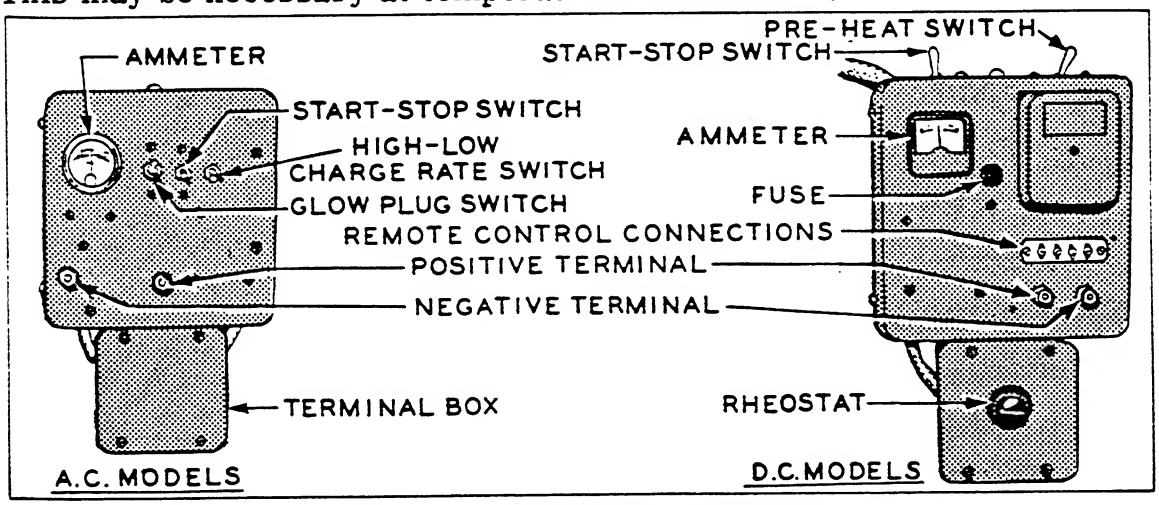


FIG. 17 - CONTROL PANELS

GENERAL FALSE START. - Should the engine fail to fire within about 30 seconds, release the switch and check the fuel system before attempting to start the engine again.

If the engine fires but fails to continue running, chances are that the fuel system has an air leak or air pocket in the fuel suction line at some point. Repeat step 8 under PREPARATION checking fuel connections for leakage. Then repeat the starting procedure.

Either of two switches may automatically stop the plant. This may result from either dangerously high coolant temperature or from complete failure of lubricating oil pressure.

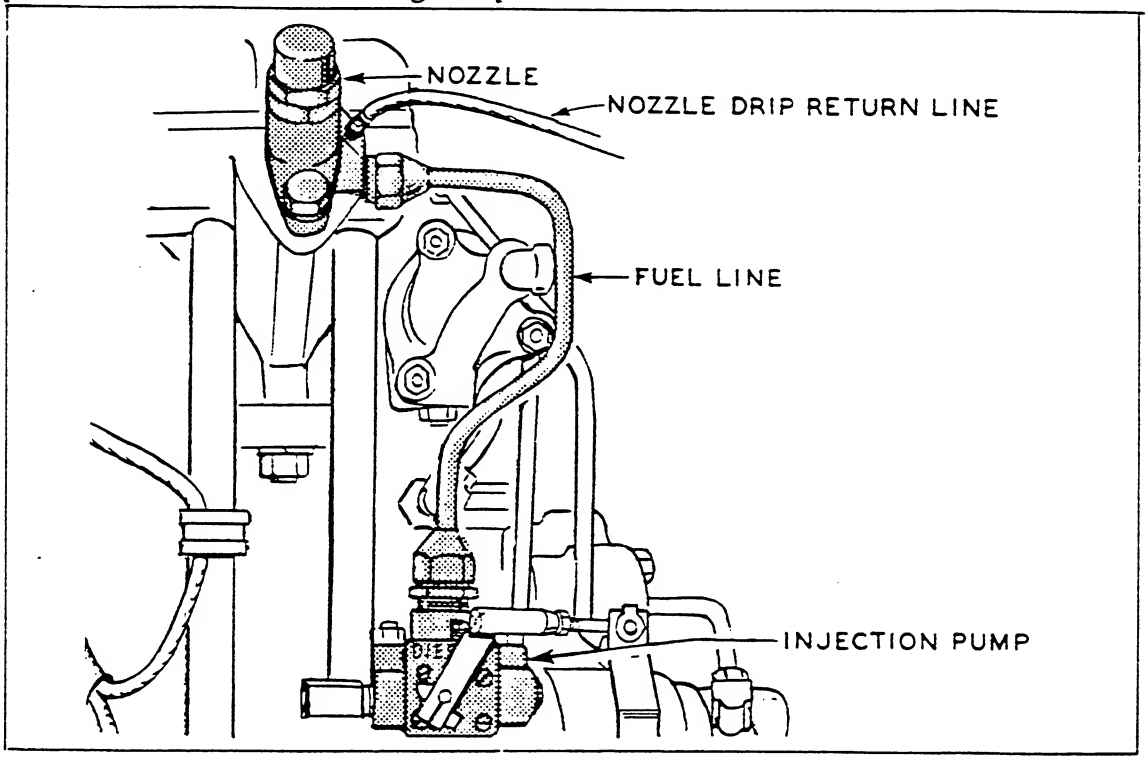


FIG. 18 - INJECTION PUMP AND NOZZLE

MAIN CAUSES OF FAILURE TO START

DISCHARGED BATTERY. - Engine will not crank electrically.

GLOW PLUG. - The glow plug which helps ignite the fuel in the combustion chamber during starting, requires a charged battery. ON plants with 24 or 32 volt cranking, the manifold heater is in the glow plug circuit and must function to drop the voltage to 12 volts for the glow plug.

DECOMPRESSION RELEASE SOLENOID. - The decompression solenoid operates the decompression release. If the solenoid fails to work for any reason, the decompression release may be operated by hand. To operate the decompression release by hand, simply throw the momentary contact switch to the START position, push the plunger on the solenoid in while the engine is rotating and turn the knurled plunger stop knob until the pin is locked in place. To stop the engine, turn the knob until free and pull out as far as it will to.

The release plunger which engages with the exhaust rocker arm is a spring-loaded separate shaft. Either the solenoid or the knob serves to push the plunger inward (compression or run position), but neither serves to pull it outward(decompression or stop position).

Failure of the solenoid to operate may be caused by the plunger becoming gummed up with oil, etc. Also the circuit to the solenoid is completed by a relay in the control panel. This relay is energized only when oil pressure is great enough to keep the contacts closed in the oil pressure switch.

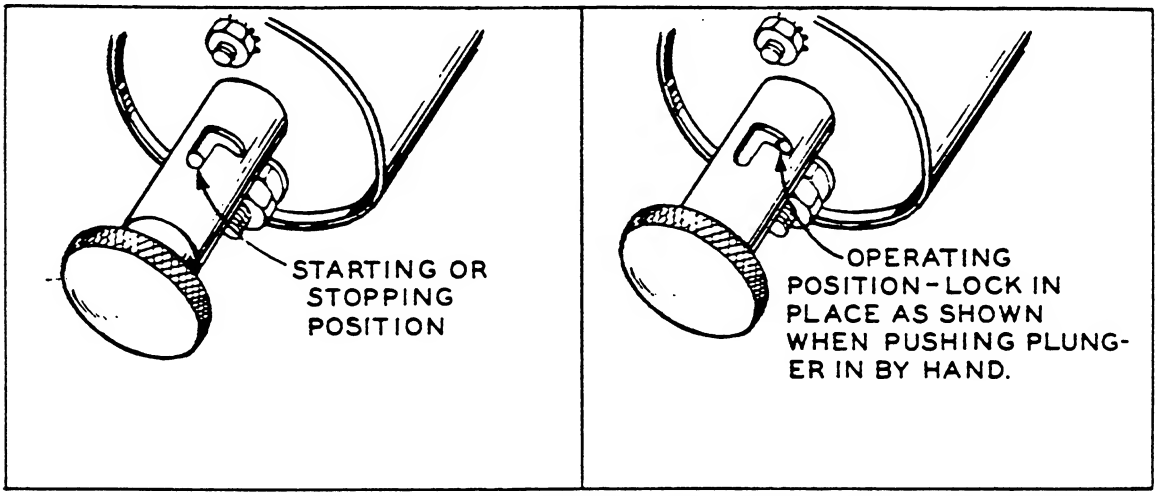


FIG. 18 A - MANUAL OPERATION OF DECOMP. REL. SOLENOID

FUEL SYSTEM. - Air pockets, air leaks and dirty fuel are three of the main causes of trouble in a Diesel engine. Check the fuel system regularly for leaks, correcting any found. When bleeding the fuel system do a thorough job. Use every precaution in storing and handling your fuel.

INJECTION PUMP AND NOZZLE. - Very little trouble should be had with the injection pump or nozzle unless dirty fuel is used. Should trouble occur, install a new part. Repairs to either unit are not practicable in the field. The nozzle only is a replaceable part of the nozzle and holder assembly, but the entire injection pump must be replaced with a new or a "rebuilt exchange" pump.

POINTS TO CHECK AFTER STARTING THE PLANT

OIL PRESSURE. - The pressure reading on the gauge should be between 20 and 30 pounds at normal operating temperature. The reading will be higher until the engine warms up. Should the oil pressure drop to 10 pounds, shut the plant off at once and determine the cause. Correct the trouble before starting the plant again.

OIL LEAKAGE. - If oil leakage occurs at the oil seals or the anti-flicker breaker plunger (a-c plants), check the breather tube check valve and the oil filler tube cap. The check valve disc must work freely. The oil filler cap must be air tight.

FUEL LEAKAGE. - Fuel leakage may occur at the nozzle base when a new engine is being started the first few times after the initial start has been made. To correct, tighten the nozzle mounting nuts. Should trouble occur with the nozzle or injection pump, install a new part.

BATTERY CHARGING RATE (A.C. Plants). - A two way switch permits the selection of two charging rates, a high rate of 6 to 9 amperes and a low rate of 2 to 4 amperes. Use the high rate if the battery is down or the plant is to be run for only a short period of time. Use the low rate if the battery is up or the plant is to be run for a long period of time.

Keep the battery in a well charged condition at all times. The gravity reading of a fully charged battery is about 1.280. The battery needs recharging if the gravity reading is 1.200 or lower. Keep the level of the electrolyte above the separators at all times. Unless the battery manufacturer specifies a different level, fill each cell with clean distilled water to a point 3/8 of an inch above the separators.

BATTERY CHARGING RATE (Dual Purpose). - The charging rate to the battery is controlled by a HIGH-LOW charge switch located near the ammeter on the plant control box. When this switch is at the HIGH position, the charging rate is a maximum of 30 A. When the switch is at the LOW position the charging rate is about 3 amperes.

CAUTION: The total a-c load on the Dual Purpose plants should not exceed 2250 watts when the charge switch is at the HIGH position. When the charge switch is at the LOW position, the full a-c capacity of 3000 watts may be used.

If the battery is in a discharged condition, throw the charge switch to the HIGH position and leave it there until the battery nears a fully charged condition. Then return it to the LOW position. Keep a close check on the battery with a hydrometer. Add distilled water as necessary to keep the level of the electrolyte above the separators. A safe level is 3/8 of an inch above the separators. If the battery manufacturer's instructions differ as to the proper level, use his recommendations.

Cycling the battery at regular intervals is recommended. Instructions for proper cycling are usually included with the batteries. If none accompanied your plant, contact the dealer from whom you purchased the batteries.

These plants produce alternating current (a-c) as well as direct current (d-c) and must operate at about 1800 rpm for the 60 cycle plants to produce the right frequency of current. NEVER INCREASE ENGINE SPEED TO INCREASE THE CHARGING RATE. Engine speed should be adjusted only to correct the rpm of the plant to obtain the right frequency.

BATTERY CHARGING RATE (Battery Charging Plants). - The battery charging plants have a rheostat in series with the shunt field circuit of the generator. The charging rate to the battery is controlled by turning the rheostat knob as required to raise or lower the charging rate.

Set the charge rate at the point where the ammeter shows the rate of charge recommended by the battery manufacturer. Allow the plant to run for a period of about one hour. Then reset the charge rate to the point where the ammeter again shows the recommended charging rate. The charge rate at any given setting will gradually get lower as the battery nears a fully-charged condition and its internal resistance increases. This gives a "tapering off" effect to the charge which is desirable. Check the ammeter once in a while during the end of the charge period. If necessary, reset the charge rate to keep the needle of the ammeter on the charge side. See "When to Operate the Plant".

ADJUSTING ENGINE SPEED - ALL PLANTS. - Engine speed should be maintained at a maximum no load speed of 1890 rpm for the 60 cycle a-c plants and the battery charging plants and 1590 rpm for the 50 cycle a-c plants. Adjustments are made by increasing or decreasing governor spring tension. Turn the speed adjusting nut in to increase spring tension (also engine speed and generator voltage) or out to decrease it. Be sure to lock the adjustment with the two hex nuts. Refer to Special Adjust.

WHEN TO OPERATE THE PLANT (A.C. Plants). - Plants of the alternating current type must be operated whenever electricity is required. When the battery is fully charged snap the charge rate switch to LOW position.

WHEN TO OPERATE THE PLANT (Dual Purpose Plants). - Plants of the dual purpose type must be operated whenever ac electricity is required, or whenever the 32 volt battery requires recharging. When the battery is fully charged snap the charge rate switch to LOW position.

WHEN TO OPERATE THE PLANT (Battery Charging Plants). - Plants of the battery charging type are operated to generate electricity which may be supplied directly to the storage battery or divided in any proportion within the output limits of the generator between the battery and the connected load, the battery receiving that portion of the current not required by the connected load. Should the connected load require more current than the generator produces, the additional current needed to operate the connected load is furnished by the battery but only for the period of time that the battery retains a high enough charge to furnish this additional current. The total electrical load maybe double the plant capacity, or even more, for the period of time that the battery remains in a well charged condition. However, the connected load should not be greater than the actual plant capacity if the battery is in a discharged condition. DO NOT OPERATE THIS TYPE OF PLANT UNLESS THE BATTERY IS CONNECTED. WHEN THE BATTERY IS FULLY CHARGED, TURN THE RHEOSTAT KNOB TO LOW RATE POSITION. The plant must be operated to recharge the battery whenever it becomes discharged.

ENGINE RACES. - Shut off the engine at once. Check the governor arm to throttle arm linkage, it may have become disconnected. Check the air cleaner for too much oil. Check the crankcase breather valve. If the valve is not free, oil may be drawn into the intake air stream.

LIGHTS FLICKER (A.C. Plants). - Check the anti-flicker breaker points as they may be dirty, burnt or improperly set. Clean the points with a fine stone and reset the point gap to .025" at full separation. Replace the points if necessary. See Fig. 21. Reset the clip on the resistor if necessary.

VALVE CLEARANCE. - Check the valve clearance at the end of the first 50 hours of running time. Check only as required thereafter.

BLACK SMOKE FROM EXHAUST. - Black smoke coming from the exhaust outlet is an indication of trouble. Should the condition exist, shut the plant off immediately and determine the cause.

Main causes of black smoke are overloading the generator, poor grade or dirty fuel, improper operation of the injection pump or nozzle, or improper fuel injector timing.

Black smoky exhaust is a normal condition with an overloaded generator. This condition can easily be remedied by simply reducing the load.

Black smoky exhaust at less than rated generator capacity indicates faulty combustion. Continued operation of the plant in this condition may result in stuck rings, blow-by at the rings or premature blackening of the crankcase oil from carbon. Faulty combustion is a direct result of loss of compression or faulty injection.

Many of the main causes of faulty combustion are listed in the "Troubles and Remedies" section. Refer to this section for possible causes should trouble of this nature occur.

STOPPING THE PLANT

Disconnect the main load from the plant and let the plant run for a few minutes at no load to allow the engine time to cool gradually before stopping the engine.

To stop the plant, hold the stop switch at STOP position until the plant has completely stopped running. Use either the switch at the plant or a remote station. If due to some electrical fault the plant will not stop by the stop switch, manually pull the decompression release plunger outward until the plant stops. The plunger may have been locked at the IN position. If for any reason the plant will not stop when the decompression release plunger is pulled OUT to the STOP position, hold the injection pump throttle arm at the closed position until the engine stops running.

If the plant is consistently operated at very light load, it is advisable to operate the plant at full load for about 5 minutes just before stopping to help dispose of carbon deposits.

If the plant will be subject to freezing temperatures and is not protected by anti-freeze, then the coolant system must be drained at: (1) the block, (2) the thermostat housing, (3) the water pump nameplate, and (4) the exhaust muffler.

HOW THE CONTROLS FUNCTION

A better understanding of what happens when you start your plant will be gained if you know what happens when you push the START button on the control box. Refer to the wiring diagram and trace the circuits as you read.

NOTE: Begining with "Spec D", all models have a manifold heater (air intake preheater), also, alternating current plants changed to a solenoid instead of a relay in the preheat circuit.

AC PLANTS. -When the switch is held at START position, battery current energizes the start solenoid and the glow plug relay. The closing of the start solenoid contacts feeds battery current to the series field windings of the generator. This causes the armature to rotate and the engine is cranked. The closing of the glow plug relay contacts feeds battery current to the glow plug and the manifold heater. The glow plug is a resistance device which aids starting by helping ignite the fuel sprayed into the combustion chamber. The glow plug operates only during cranking or when the glow plug momentary contact switch is depressed as may be necessary to preheat for starting at lower temperatures.

When cranking builds up lubricating oil pressure, the contacts within the oil pressure switch are held closed to complete the circuit which energizes the decompression release relay. The closing of the decompression release relay contacts, completes the circuit which energizes the decompression release solenoid located on the cylinder head. The magnetic pull of the solenoid moves its spring loaded plunger inward. The exhaust valve and rocker arm are released and compression takes place.

Generator excitation voltage builds up after starting as the plant comes up to speed. Then the operator may release the start switch and the decompression release relay continues to be energized by the excitation current. Excitation current also energizes the reverse current relay which completes the circuit to the battery. Excitation current then recharges the battery as controlled by the charge rate switch.

With the engine running at recommended speed, the generator produces current up to its rated capacity. Alternating current generators produce both alternating current and direct current. The direct current is used to excite the shunt field and for battery charging purposes. Alternating current is the main current produced and is taken off the collector rings of the armature by brushes. Leads are connected to the brush terminals and are brought out of the generator frame at a convenient point where they can easily be connected to the main line wires or to a fused switch or circuit breaker. Generator leads of a single phase 2 wire plant are marked M1 and M2, M2 being grounded. Leads of a single phase, 3 wire plant are marked M1, M2 and M3, M2 being grounded.

Direct current flows through the series field lead marked "S1" to the terminal between the two resistors where the current can follow one of the two paths depending on the position of the Hi-Lo charge switch.

If the charge switch is at the "LO" position the direct current will flow through the 2.5 Ohm resistor and through the coil of the charge relay to ground. Energizing of the charge relay coil causes its contacts to close and direct current flows through these contacts, through the ammeter to the BAT. POS. terminal, through the battery to the BAT. NEG. terminal to ground completing the charging circuit.

If the charge switch is at the "HI" position the direct current will flow through the 1.5 Ohm resistor, through the charge switch and back to the charge relay, following the same course from the relay to ground described in the foregoing paragraph.

All direct current used while the plant is running (including that for battery charging) comes from the series field winding of the generator.

A lead marked "F2" runs from the shunt field to the terminal of the anti-flicker resistance unit, to the anti-flicker breaker points and to ground.

A single cylinder engine has a tendency to surge on the power stroke. The purpose of the anti-flicker resistance unit and breaker is to equalize the output current of the generator during the power stroke of the engine by reducing field strength just enough to compensate for the surge in voltage during the power stroke.

When the engine is turning over on the exhaust, intake, and compression strokes, the contact points of the anti-flicker breaker mechanisms are closed and current from the shunt field flows through the contact points to ground. The resistance in the lead wire is very low and does not affect the excitation voltage. However, the contact points of the anti-flicker breaker mechanism open on the power stroke of the engine and current from the shunt field flows through the resistance unit to ground. This weakens the field strength just enough to compensate for the surge in voltage during the power stroke and prevents flickering lights.

The engine stops when the switch is held at STOP position and compression no longer takes place. Refer to Stopping The Plant under OPERATION.

When the switch at a remote station grounds terminal 2 to terminal 1 the plant stops, or when terminal 3 is grounded to terminal 1 the plant cranks.

The high-water temperature cut-off switch provides plant protection in case of dangerously high coolant (water) temperature. It automatically shorts out the decompression-release-solenoid relay to stop the plant. Complete failure of oil pressure will open the switch in the decompression release solenoid circuit to stop the plant.

WARNING: The use of the oil pressure switch is not intended for a safety device. Because it must make contact during cranking, the calibration is necessarily for very low pressure. Therefore it will not be adequate protection in case of a gradually diminishing oil pressure or too low oil level.

DUAL PURPOSE PLANTS (115V.AC/32V.DC). - The circuits for the dual purpose plants are similar to those for the straight ac plants except for various resistance units.

The Charge Circuit differs in that a 4 Ohm resistor is used for LO charge rate and no resistor is used for HI charge rate.

The Glow Plug Relay Circuit differs in that a resistor ahead of the relay drops the voltage to 12 volts.

The Glow Plug Circuit differs in that a manifold heater is used to drop the voltage to 12 volts. At the same time the manifold heater serves to warm incoming air during the cranking cycle.

BATTERY CHARGING PLANTS. - The 24 or 32 volt battery charging plant has an UNGROUNDED electrical system. In this system all electrical components of the plant (except the glow plug which operates only during starting) are electrically insulated from the engine and control box. Leads are used to complete the circuits back to generator Lead A2 and battery ground.

When the switch is held at START position, battery current energizes the start solenoid and the glow plug relay. The closing of the start solenoid contacts feeds battery current to the series field windings of the generator. This cuases the armature to rotate and the engine is cranked. The closing of the glow plug relay contacts feeds battery current to the glow plug. Also the glow plug relay completes a fused circuit from battery ground to engine ground for completing the glow plug circuit. The glow plug is a resistance device which aids starting by helping ignite the fuel sprayed into the combustion chamber. The glow plug operates only during cranking or when the glow plug momentary contact switch is depressed as may be necessary to preheat for starting at lower temperatures. Also in the glow plug circuit is a manifold heater which drops the voltage to 12 volts at the glow plug and at the same time serves to warm incoming air during the cranking cycle.

When cranking builds up lubricating oil pressure, the contacts within the oil pressure switch are held closed to complete the circuit which energizes the decompression release relay. The closing of the decompression release relay contacts, completes the circuit which energizes the decompression release solenoid located on the cylinder head.

The magnetic pull of the solenoid moves its spring loaded plunger inward. The exhaust valve and rocker arm are released and compression takes place. Air is drawn into the combustion chamber and compressed and fuel is then injected into the combustion chamber. Compressing the air in the combustion chamber generates terrific heat and the fuel ignites from this heat as it is injected, starting the engine.

As the engine builds up speed the current produced by the generator rises to a usable voltage and flows through A1 to terminal G + of the reverse current relay, through the coils of the reverse current relay to ground energizing the coils. Energizing of the coils closes the contacts of the reverse current relay and the current from the generator flows through the contacts of the reverse current relay, through terminal B +, the ammeter, the battery positive terminal, the battery, the battery negative terminal, lead A2 to the generator and to ground completing the battery charging circuit.

Releasing the START button breaks the starting circuit and cranking stops.

The rheostat connected in series with the shunt field winding of the generator controls the output of the generator by varying the strength of the shunt field. This is done by varying the amount of resistance in the field circuit through different settings of the rheostat, the more resistance in the field circuit, the less the generator output.

The engine stops when the switch is held at STOP position and compression no longer takes place. Refer to Stopping The Plant under OPERATION.

When the switch at a remote station grounds terminal 2 to terminal 1 the plant stops, or when terminal 3 is grounded to terminal 1 the plant cranks.

The high-water temperature cut-off switch provides plant protection in case of dangerously high coolant (water) temperature. It automatically shorts out the decompression-release-solenoid relay to stop the plant. Complete failure of oil pressure will open the switch in the decompression release solenoid circuit to stop the plant.

WARNING: The use of the oil pressure switch is not intended for a safety device. Because it must make contact during cranking, the calibration is necessarily for very low pressure. Therefore it will not be adequate protection in case of a gradually diminishing oil pressure or too low oil level.

FUEL KNOCK

Reference is made under starting instructions to a sharp knock that occurs when the engine is first started. This knock will usually diminish gradually as the engine warms up. However, under such conditions as a cold engine, too much fuel or too little fuel metered into the combustion chamber by the nozzle, an air leak in the suction side of the fuel system or to a change in the type of fuel used, the engine may continue to knock even after it is thoroughly warmed up. To remedy, proceed as follows:

(1) Check for air leaks in the suction side of the fuel system. Any air leaks that are found should be corrected and the fuel system bled to remove all air from the system. The transfer pump should be checked. The pump must provide a continuous supply of fuel at all times. Replace the pump if necessary. A repair parts kit is available.

(2) Adjust the nozzle for best operation for the type of fuel being used. The nozzles are adjusted at the factory according to the type of fuel used for the test run. Make the nozzle adjustment as described under the heading NOZZLE ADJUSTMENT under the Adjustment section of this manual.

(3) Close ventilator openings as necessary during cold weather operation to allow the engine to warm up to normal operating temperature. Care should be taken not to close these ventilators too much. Even though the unit is installed in a room without heat it will generate a large amount of heat itself and may eventually overheat unless sufficient ventilation is provided. Readjust ventilator openings from time to time until the unit operates best without overheating. Best operating conditions are with room temperatures of 50°F. to 70°F. for cold weather operation.

RUNNING TIME METER

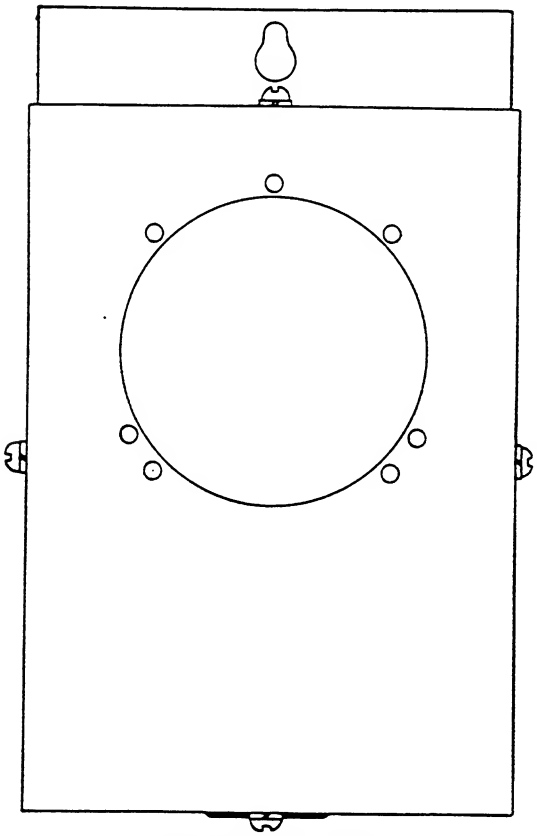
Don't Guess - Know how many hours your plant runs, so that you can change oil and service the plant at proper intervals.

This meter will be an investment rather than an expense. Simple to connect. This meter runs only when the plant is operating.

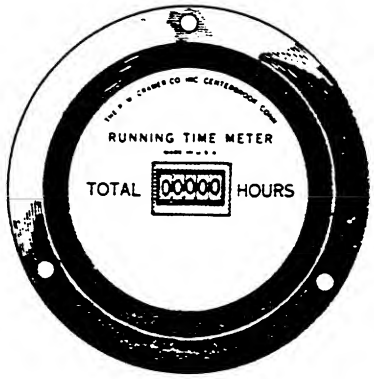
PART NO.	USED WITH PLANT
302-212	60 Cycle, 115 V. A.C. (Replaces #302-68).
302-102	50 Cycle, 115 V. A.C.
304-99	Resistor - adding to either meter above makes it suitable for 230 V. use.

Meters listed above are 3-1/2 inch diameter, and are for flush mounting on panel; fit into 2-29/32 inch hole. For wall mounting, order separately.

301-500 Instrument Box



INSTRUMENT BOX



RUNNING TIME METER

COLD TEMPERATURE SUGGESTIONS

Full Diesel engines fire on compression alone and starting problems may occur at temperatures of 50° F. and below. **Read the following paragraphs** carefully. They contain many helpful hints on cold weather starting.

Refer to Fresh Water Cooling under INSTALLATION.

Drain the crankcase oil while the engine is warm and refill the crankcase with heavy duty detergent SAE No. 5 oil. Start the engine and let it run for 1/2 hour. For heavy duty operation or continuous service, use SAE No. 30 oil and provide some means of heating the space in which the plant is located.

Be sure the fuel used has a low pour point (at least 10 degrees lower than the prevailing temperature) and will flow freely and not congeal in the lines. Fuel tends to congeal in the filters and fuel lines at low temperatures. If trouble of this nature occurs, warm the fuel or change to a No. 1 Diesel fuel (or alternate) having a lower pour point.

The lowest temperature at which the fuel will flow through a pipe is known as the pour point or congealing point.

The fuel in the combustion chamber is ignited by the rise in temperature of the air in the chamber due to compression. A glow plug helps ignite the fuel. This glow plug operates whenever the switch is held at ON position, or whenever the plant is being cranked electrically. Hold this switch at the ON position for a period of about 1 minute just before the plant is to be started.

Any means of increasing the temperature of the air being drawn into the combustion chamber will aid starting.

Use this method for emergency only!! Should the engine fail to start in cold weather when using the glow plug it has been found that the engine will usually start if a small amount of warm SAE No. 10 oil is put into the combustion chamber just before starting the engine. Unscrew the plug in the air cleaner adapter, insert the nozzle of a small pressure type oil can into the adapter

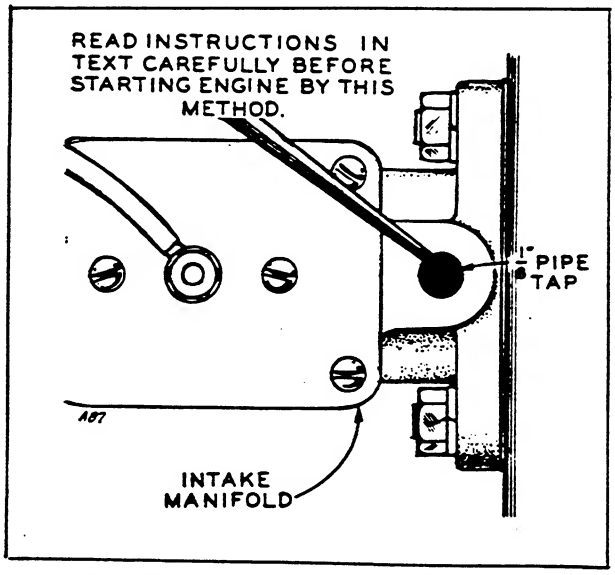


FIG. 19 - USING MOTOR OIL OR ETHER TO START THE UNIT

and pump 8 to 10 squirts of oil into the adapter. Then start the engine in the normal manner. If the engine fires but fails to continue running, keep the engine cranking and continue to pump oil from the pressure type can into the adapter for 30 or 40 seconds, more if necessary. Should the engine fail to keep running now, chances are the fuel system is fouled up in some manner. Check the entire fuel system. If the fuel is at fault, check with your supplier. See that the fuel is clean and has a low enough pour point for the prevailing temperatures.

CAUTION: Be careful not to use too much oil when starting the engine by this method as serious damage may result due to too heavy a charge in the combustion chamber.

NOTE

In extremely cold weather ether may be used as described above, either alone or mixed with SAE No. 10 oil. However, use only about 1/5th as much as you would if straight oil were used.

If frequent starting at temperatures below 50°F. is required, it is a recommended to install a special primer kit to use a starting fluid with a low kindling point.

Fuel does not flow freely in cold weather and air locks may occur often. When bleeding the fuel system be sure to clear all air pockets.

Crank the engine a few revolutions by hand to free it up before attempting to start it.

The battery capacity decrease with lowering temperatures. Because of this it is necessary to keep the battery fully charged at all times in order to crank a cold engine fast enough to start it. A temporary addition of another battery, connected in parallel, during the starting period will make quite a difference in cranking speed. Remove this booster battery as soon as the plant is started.

Check the charged condition of the battery often with a dydrometer. Batteries will freeze between temperatures of 20°F. above zero and 50°F. below zero, depending on the state of charge.

Drain, clean and replace element in the fuel filter only as necessary to keep the fuel clean. Remember that any foreign particles that enter beyond the filter during cleaning will be forced into the injection pump and will probably cause trouble.

Keep all fuel tank screens clean.

Keep supplies of fuel free of water. If fuel containing water is used, it may freeze and close off the fuel supply.

Let the engine warm up slowly before applying the load. Watch the oil pressure carefully. Don't apply any load until the oil circulates freely.

HOT TEMPERATURE SUGGESTIONS

Keep the level of the oil in the engine crankcase at or near the full mark at all times.

Be sure there is ample ventilation so that radiated heat from the engine is not recirculated, causing the engine to overheat. Provide more or larger air inlets or air outlets if necessary.

Keep all cooling surfaces clean and free of dust, dirt and grease or oil.

DUST AND DIRT

Check plant operation more often and service as necessary.

Clean the air cleaner as often as necessary to assure a free passage of air.

Check the commutator and brushes of the generator often and see that the brushes ride freely in their holders and make good contact. See GENERATOR under Maintenance and Repair for service instructions.

Keep supplies of fuel and oil in airtight containers.

Keep the plant as clean as practicable.

ONAN DIESEL ENGINE SERVICE CHART

The following recommended Engine Service Chart may be used as a guide for servicing ONAN Diesel Engines.

The chart is based on favorable operating conditions. The actual service period may be somewhat longer or shorter than shown - depending on operating conditions.

SERVICE REQUIRED	HOURS OF OPERATION										
	100	200	300	400	500	600	700	800	900	1000	2000
Change oil (check level daily)	x	x	x	x	x	x	x	x	x	x	
*Service air cleaner	x	x	x	x	x	x	x	x	x	x	
Clean crankcase breather	x	x	x	x	x	x	x	x	x	x	
Replace oil filter cartridge	x	x	x	x	x	x	x	x	x	x	
Check anti-flicker points (AC only)					x					x	
Inspect generator brushes, commutator, slip rings		x		x		x		x		x	
Clean primary fuel filter										x	x
Drain sludge secondary fuel filter										x	x
Check valve tappets	x									x	x
Grease generator bearing (if not seal bearing)										x	x
Clean engine and oil base											x
Clean injector nozzles	As Required										
Replace secondary fuel filter	As Required										
Grind valves and remove deposits	As Required										
Replace valve, piston rings, etc.	As Required										
Replace water pump rotor (marine units only)	As Required										

* Check the air cleaner often.

If it is necessary to remove parts for inspection and gaskets are disturbed they should be replaced with new ones.

Periodic Inspection: For Loose or Poor Connections, Fittings, etc.

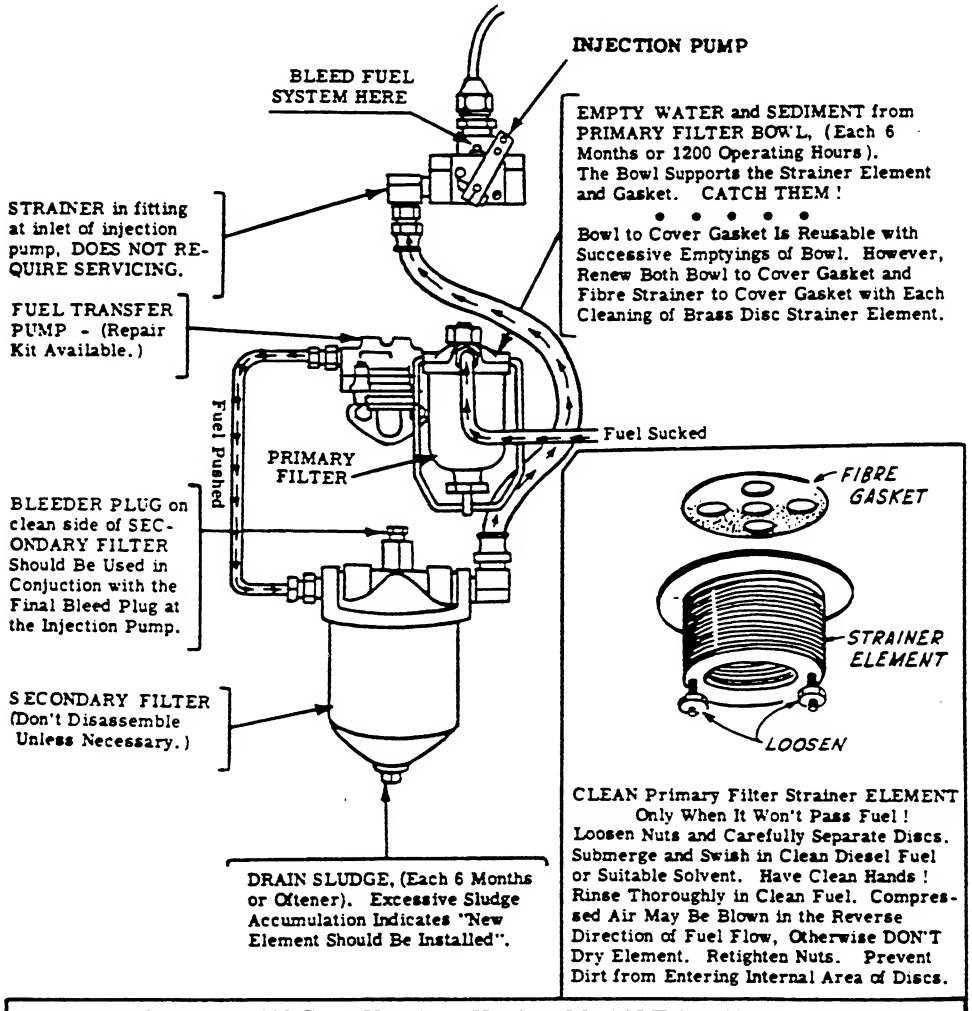
Recommended Oil: Heavy Duty Detergent or Oil designated for Service DG, DS or MS/DG. Use the proper SAE number oil for the lowest temperature at the engine as expected at the time of starting. Above 40°F. (4°C.) use SAE 30, Below 40°F. (4°C.) use SAE 10.

Recommended Fuel: No. 2 furnace oil. Premium Diesel fuels are not required.

Alternate Fuel: No. 1 furnace oil (distillate and range oil) and kerosene may be used but one quart (U.S. Measure) of SAE No. 30 lubricating oil should be added to each 25 gallons of such fuel to provide lubrication for fuel injection equipment.

THE BEST PROTECTION AGAINST FILTER TROUBLE IS THE USE OF CLEAN FUEL

NOTE: Filters Should Be Cleaned Only When Necessary. The Primary Filter May Have To Be Cleaned Several Times Before It Becomes Necessary To Clean The Secondary Filter.



WHEN CLEANING FUEL SYSTEM INTERNAL PARTS, "SWISH" THEM THOROUGHLY IN CLEAN DIESEL FUEL. DO NOT ATTEMPT TO WIPE DRY. HAVE HANDS CLEAN. BE THOROUGH !

FIG. 20 - FUEL SYSTEM AND FILTER SERVICE

Certain services must be performed periodically if your plant is to continue operating efficiently and economically. Service periods are based on hours of running time under normal operating conditions. For extreme conditions of load, temperature, dust, dirt, etc., service more often.

DAILY SERVICE

Perform the following services daily or at the end of each 8 hours of running time, whichever occurs first.

(1) Check the fuel supply often enough to avoid running out of fuel. Use only clean No. 2 Furnace Oil or alternate fuels as recommended.

(2) Check the oil level in the crankcase. Refill with heavy duty detergent SAE No. 30 oil if necessary. Be sure the oil filler cap is replaced securely.

(3) Keep the plant clean.

WEEKLY SERVICE

Perform the following services weekly or at the end of each 50 hours of running time, whichever occurs first.

(1) Change the crankcase lubricating oil every 100 hours of running time unless sludge formation or condensation forms during cold weather operation. Then change oil more often. Change the oil filter cartridge each time the crankcase oil is changed. Remove the drain plug from the oil filter and drain the old oil from the filter before replacing the cartridge.

(2) Place a drop of SAE No. 30 oil on each joint of the governor to throttle linkage.

(3) Check the level of the fluid in the starting batteries. Add distilled water to bring the fluid to 3/8" above the separators if necessary.

(4) Necessary air cleaner (silencer) servicing is greatly dependent upon the installation and operating conditions. Detach and submerge the packing in Diesel fuel, allow it to drain and squirt a limited amount of oil on the packing not heavier than SAE No. 10.

(5) Tighten all loose nuts, bolts, connections, etc.

(6) Check the valve clearance at the end of the first 50 hours of running time. Reset the valve clearance if necessary.

MONTHLY SERVICE

Perform the following services monthly or at the end of each 200 hours of running time, whichever occurs first.

(1) Check the anti-flicker breaker points and condenser of the alternating current plants. Clean the points with a fine stone and reset the point gap to .025" if necessary. If the points are badly pitted or burnt, replace them. Burnt points are usually an indication of a faulty condenser. Replace the condenser if it tests faulty. If the lights still flicker, adjust the clip on the resistor to correct.

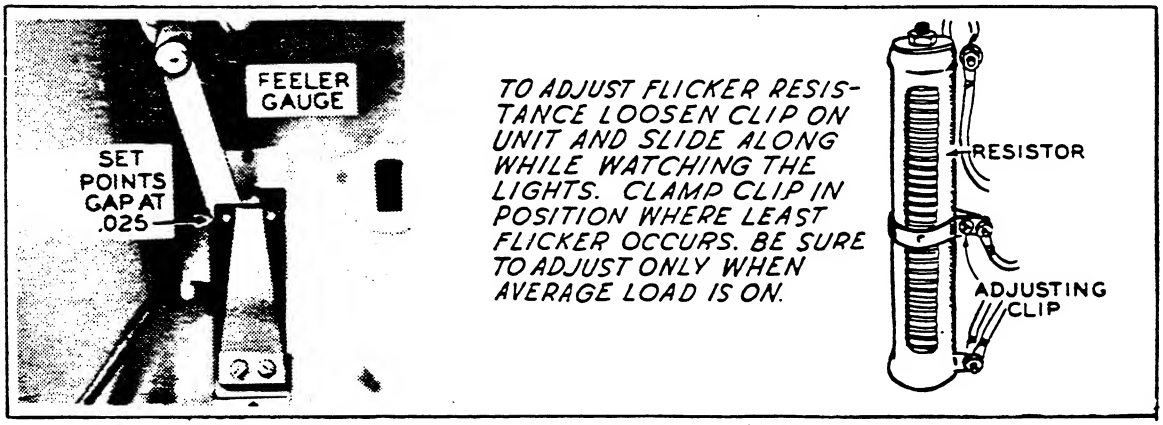


FIG. 21 - SERVICING THE ANTI-FLICKER BREAKER MECHANISM - AC MODELS

(2) Check the generator brushes. Brushes worn to 5/8 inch in length should be replaced.

(3) Check the commutator and collector rings (a-c plants only). Brush surfaces must be smooth and cylindrical to assure good brush contact. See GENERATOR under the heading Maintenance and Repair for repair instructions.

(4) Inspect exhaust connections. Tighten or replace parts requiring it.

(5) Valve grinding is a service that must be performed periodically if your plant is to continue operating efficiently. There is no set period for performing this service. However it is recommended that the following tests be made whenever the plant begins to lose power or consume an excessive amount of fuel or oil.

Work the decompression solenoid plunger manually so that the exhaust valve is free to operate. Then insert the hand crank into the mechanism provided for this purpose at the front of the engine, engage the crank, and crank the engine over slowly. If the compression is good, it will require a lot of strength to crank the engine past the compression stroke. If the compression is poor, the engine can be cranked past the compression stroke although not easily due to the high compression ratio of the engine.

Loss of compression may be due to a poor valve condition, worn or sticking pistons rings, worn piston ring grooves, or to worn cylinder walls. If the exhaust valve is leaking, it can be heard at the exhaust outlet on the plant. If the intake valve is leaking, a hissing noise will be heard at the air cleaner opening. A compression leak past the piston rings can be heard at the oil filler opening.

(6) Necessary fuel filter service is dependent upon the cleanliness of the fuel used. Engine operation is the best indication of necessary filter service. Refer to the page herein on SERVICING THE FUEL FILTER. The primary filter may have to be serviced several times before it is necessary to service the secondary filter. The factory recommends having a spare secondary fuel filter element on hand for use if trouble occurs. More damage may result in dirt getting into the fuel system during periodic servicing of the filters than might be gained by a periodic service aimed at preventing trouble.

Fuel filters must be assembled air tight. Bleed the fuel line in accordance with paragraph 8 under preparation, after the fuel filter is serviced.

Remember any dirt allowed to pass the fuel filter might clog the fuel injection pump or nozzle. Water and sediment will settle to the bottom of the fuel filter bowl when the plant is stopped. To determine if plant failure is due to air leakage at the filter, raise the fuel supply above the level of the fuel filter.

SEMI-YEARLY SERVICE

Perform the following services every six months or after each 1200 hours of running time, whichever occurs first.

(1) Check the generator brush rig to see that it has not shifted from its original position. Operation of the generator with the brushes out of neutral position causes rapid brush wear and excessive arcing of the brushes.

Markings were made at the factory to indicate the neutral brush position. Two different methods of marking the "neutral" brush position are used on these plants as shown in Fig. 48. Turn to the GENERATOR section under Maintenance and Repair for complete instructions.

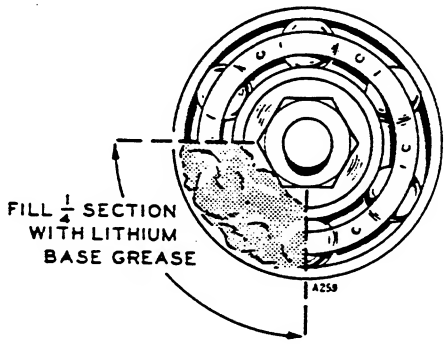


FIG. 22 - SERVICING THE GENERATOR BEARING

(2) Service the generator ball bearing, on earlier models, at intervals determined by the type of grease used. Later models have a double sealed pre-lubricated bearing which does NOT require future greasing.

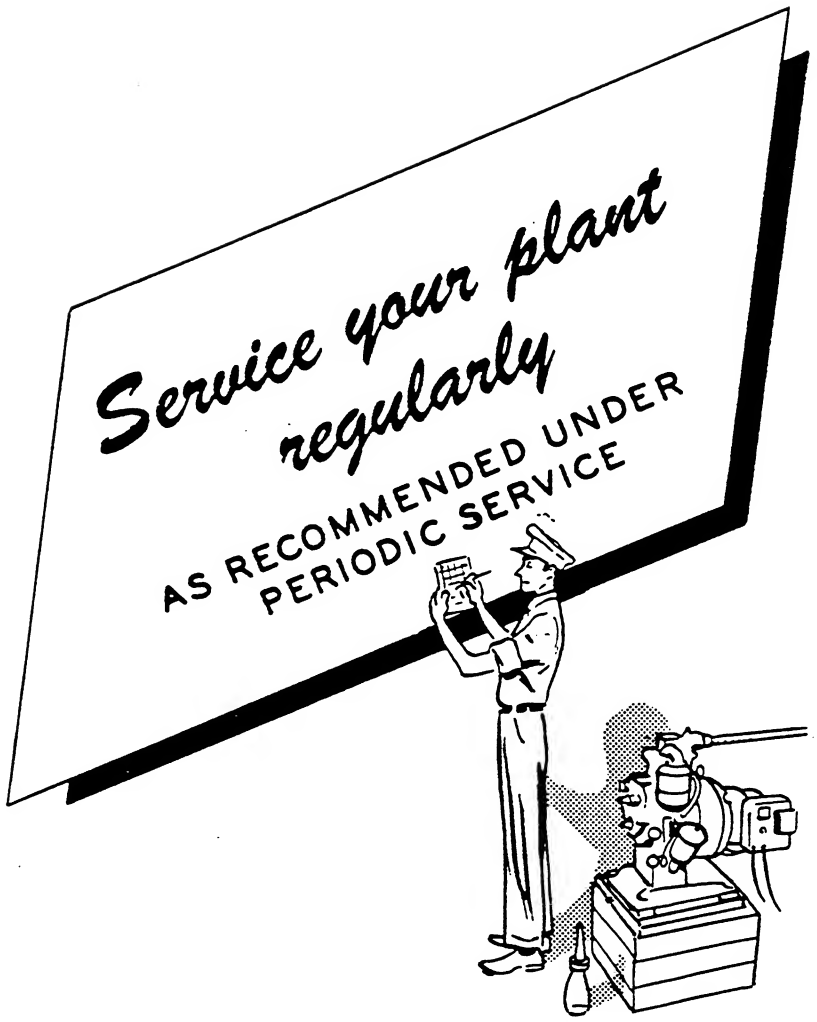
Clean all dirt from around the generator bearing cover and remove the cover. On certain models the cover is removed by simply prying it out. On other models the cover is held in place by two screws.

Lithium base type bearing grease is used by and recommended by the factory. This bearing grease is superior because it does not run, and will not become hard or caked when used at temperatures ranging from minus 90°F. to 125°F. With lithium base grease, service the generator ball bearing each 5000 operating hours or each 2 years. Only a small quantity of this grease need be used. With a clean finger, remove as much as possible of the old grease. Force fresh grease into a 1/4 section of the bearing. DO NOT fill the entire bearing. Do not put a reserve of grease in the bearing recess nor in the bearing cover. IF dirt has gotten into the bearing, remove the bearing and clean it in a good solvent. Dry the bearing thoroughly and reinstall it.

If ordinary good ball bearing grease is used, service the generator ball bearing each 1200 operating hours or each 6 months. With a clean finger remove all the old lubricant and work approximately one tablespoonful of new bearing lubricant into the bearing. Again clean out the bearing, then refill about 1/2 full, packing the lubricant well into the lower half of the bearing.

Take extreme care to avoid getting any dirt into the bearing. Replace the large plug securely.

(3) Inspect the exhaust system for carbon deposits. Carbon removal is necessary especially if the plant is consistently operated at very light load. Operating at full load for about 5 minutes just prior to stopping the plant will help eliminate carbon accumulation.


Service your plant regularly
AS RECOMMENDED UNDER PERIODIC SERVICE

GOVERNOR

The governor is set at the factory to maintain close regulation of engine speed and generator voltage, within the limits given herein, and according to the plant nameplate rating. The governor seldom requires additional adjustment. If necessary, it should be adjusted by someone properly equipped and experienced with generating plants. Study carefully the following paragraphs and check each point in the order given.

GOVERNOR ARM AND LINKAGE. - Check the governor arm and linkage and the throttle lever for a binding condition and for excessive slack or wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the plant is idle. If either of these conditions exist, find out at which point the trouble lies and adjust or replace the part as required.

The linkage and the position of the governor arm must synchronize the travel of the governor and the throttle lever so that the governor is at the wide open position when the throttle is at the wide open position and the governor is at its closed position when the throttle is at its closed position. The position of the governor arm on its shaft is fixed and the adjustment is made through the connecting linkage. Turn the governor arm away from the injection pump as far as it will go to place the governor shaft yoke against the governor cup. Then with the tension of the governor spring holding the arm at the wide open position, adjust the linkage by turning the ball joint farther on or off the link to hold the throttle lever so that the arm of the stop is about 1/32" from the stop screw (wide open position of the throttle shaft)when the engine is stopped. The engine starts at wide open throttle. Be sure there is no looseness or binding at any point. See Figure 23.

THROTTLE LEVER AND THROTTLE LEVER STOP. - The throttle lever should never require readjustment unless it has become loosened or has been removed as during parts replacement procedures. On most engines the throttle lever position is exactly parallel to the injection fuel line (to nozzle) when the shaft is held so that the nameplate stop screw is exactly midway between the arms of the throttle stop. The adjustment is the same wether the lever and stop are brass or steel material. If lever adjustment is necessary, loosen the lever screw, attain the correct lever position, retighten the screw, then if necessary, adjust the governor linkage length.

The throttle lever stop is also adjustable but the position of this stop should never be changed or altered in any maner as it fixes the position of the shaft which in turn determines the folw of fuel to the injector.

Should the throttle-lever-stop ever work loose or be loosened accidently, adjust it as follows.

(1) Crank the engine by hand until the TC mark on the flywheel and the mark on the flywheel housing are in line on the compression stroke, then back up 1/6 of a turn (60°) against rotation.

(2) Disconntect the fuel line from the injection pump outlet.

(3) Remove the valve from the injection pump outlet.

(4) Remove the throttle lever and loosen the throttle stop socket screw so that the shaft will be free to turn.

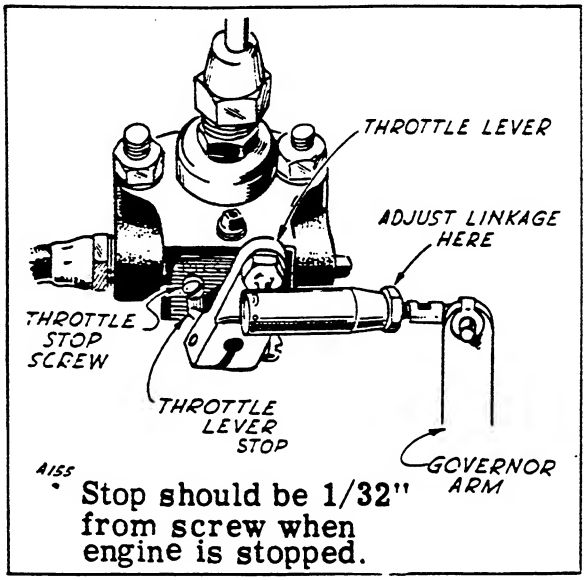


FIG. 23 - ADJUSTING THE THROTTLE LEVER

(5) Place a .030" feeler gauge over the throttle stop pin or screw and turn the throttle stop to the left until it rests against the gauge.

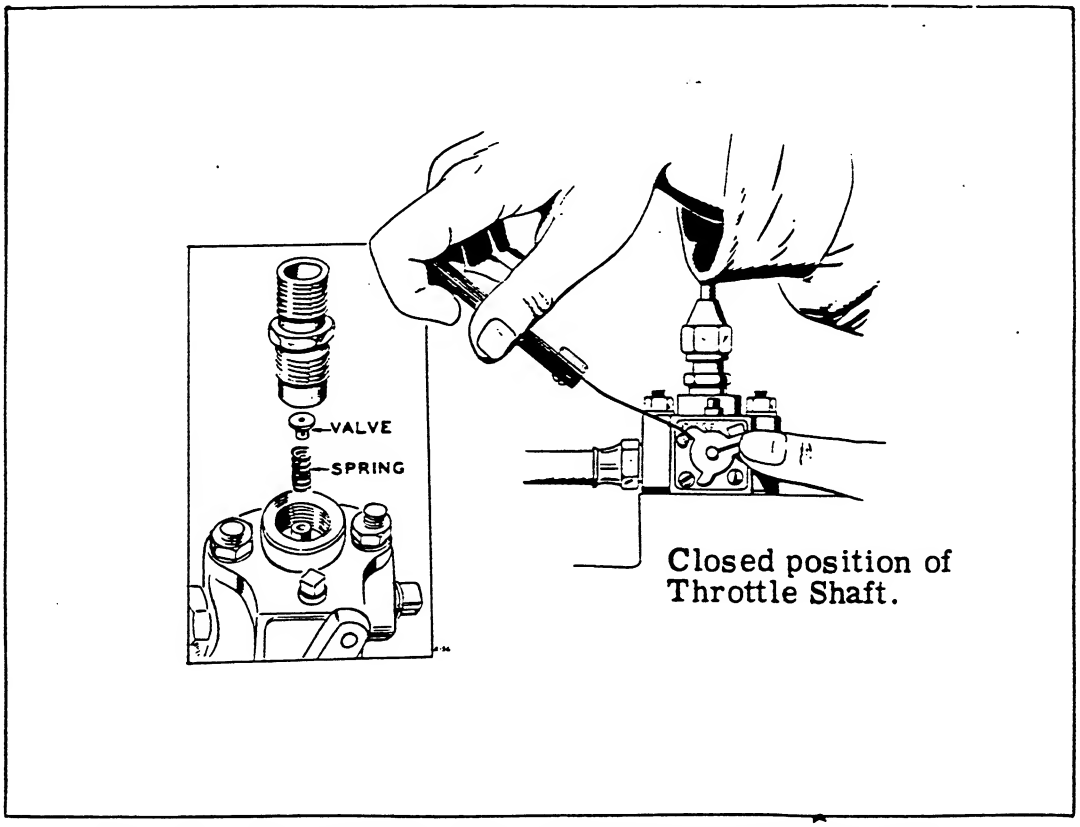


FIG. 24 - ADJUSTING THE THROTTLE LEVER STOP

(6) Have someone work the manual primer on the fuel transfer pump. Use a steady motion so that the flow of fuel will be fairly steady.

(7) Slowly turn the shaft to the right until fuel flows freely from the injection pump outlet.

(8) Slowly turn the shaft to the left until the fuel stops flowing. NOTE: If the flywheel has been turned too far or not far enough before TC mark the fuel may not stop flowing at any point. If this happens turn the flywheel a few degrees one way or the other to correct the condition.

(9) Without distrubing the position of the shaft, tighten the throttle stop socket screw securely to lock the shaft in place.

(10) Replace the throttle lever and reset the position as described in a previous paragraph. Adjust the connecting linkage if necessary.

(11) Replace the valve in the injection pump outlet and connect the fuel line to complete the job.

GOVERNOR SPRING. - Due to the fact that springs become fatigued and lose their original tension from long usage it sometimes becomes necessary to replace the governor spring to get proper regulation . It is difficult to determine whether or not a spring is fatigued. Usually if all other adjustments have been properly made and regulation is still erratic, the troubles can be corrected by replacing the governor spring and resetting the sensitivity and speed adjusting screw.

GOVERNOR SENSITIVITY ADJUSTMENT. —The position of the sensitivity adjusting screw controls the travel and leverage of the governor spring and determines the rpm spread between no load and full load. This rpm difference should not be more than 60 rpm (for a-c current). Check with a tachometer.

To increase the rpm between no load and full load, turn the sensitivity screw out. To decrease the rpm between no load and full load, turn the sensitivity screw in. See Fig. 25. Always recheck engine speed after making a sensitivity adjustment.

A hunting condition (engine alternately increasing and decreasing speed) may result from the rpm between no load and full load being too low. Should this condition exist, turn the sensitivity screw out until the condition is corrected. Regulation is better with the end of the spring held closer to the governor shaft but the tendency to hunt is increased. Make the adjustment that gives the best regulation with no hunting. A more likely

cause of the engine hunting is lack of fuel due to improper adjustment or blockage of the fuel system.

GOVERNOR SPEED ADJUSTMENT. - The speed at which the engine operates is determined by the tension applied to the governor spring. Engine speed also determines the output voltage of the generator. Increasing spring tension increases engine speed and generator voltage. Decreasing spring tension decreases engine speed and generator voltage. No load engine speed should be maintained as given below. Check engine speed with a tachometer.

Speed tests and voltage tests should be made when the plant is warm, running for at least one hour before the test is made.

Nominal engine speed and generator voltage should be as follows:

(1) A.C. PLANTS: Maximum no load engine speed should not be more than 1920 rpm for 60 cycle plants nor more than 1710 rpm for 50 cycle plants.

Maximum no load voltage should not be more than 126 volts for 115 volts circuits nor more than 252 volts for 230 volt circuits.

Minimum engine speed at full rated generator capacity should not be less than 1710 rpm for 60 cycle plants nor less than 1500 rpm for 50 cycle plants.

Minimum voltage at full rated generator capacity should not be less than 110 volts for 115 volt circuits nor less than 220 volts for 230 volt circuits.

Maximum speed drop from no load to full load should not be more than 60 rpm.

(2) BATTERY CHARGING PLANTS: Engine speed of the battery charging plants should be set at 1890 rpm. Preferred speed with load connected is 1800 rpm.
If a speed adjustment is needed, turn the speed adjusting nut in to increase engine speed and generator voltage or out to decrease engine speed and generator voltage. See Fig. 25. Be sure to lock the adjustment with the two hex nuts.

GOVERNOR ADJUSTMENT PROCEDURE. - Check the position of the governor arm, the throttle lever and the governor linkage. Make adjustments as instructed under GOVERNOR ARM AND LINKAGE and THROTTLE LEVER AND THROTTLE LEVER STOP, if necessary.

After the governor arm, throttle lever and linkage have been carefully adjusted as instructed, start the plant and check the no load rpm. Correct as instructed under SPEED ADJUSTMENT, if necessary.

When all other adjustments have been completed, check the rpm between no load and full load. Make adjustments as instructed under SENSITIVITY ADJUSTMENT, if necessary.

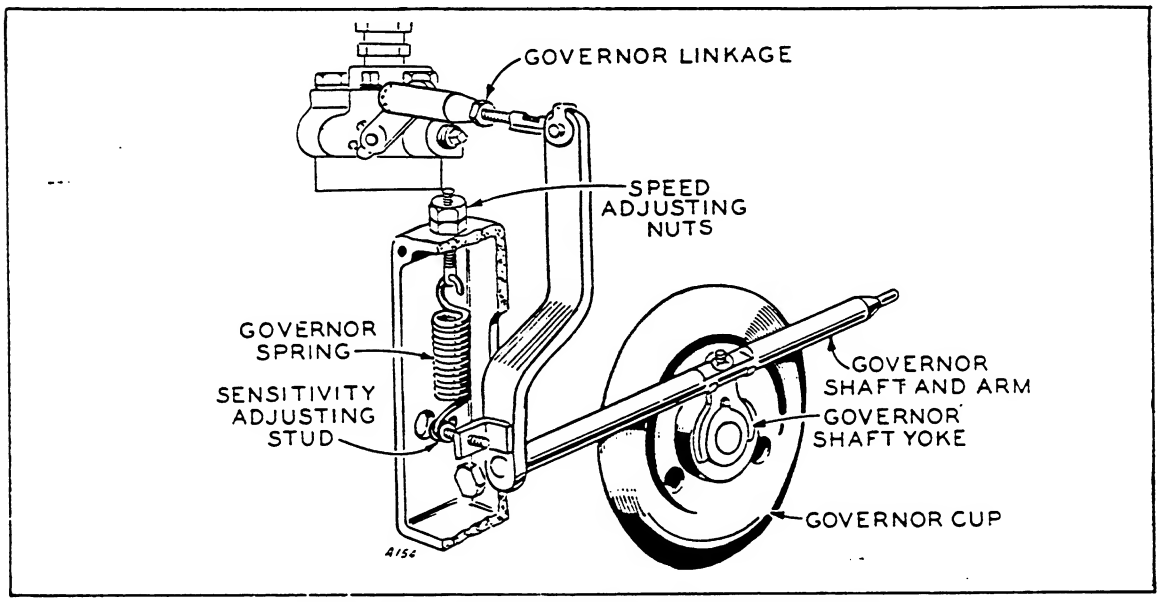


FIG. 25 - GOVERNOR ADJUSTMENT

ADJUSTING VALVE CLEARANCE

(1) Remove the top plate from the cylinder head.

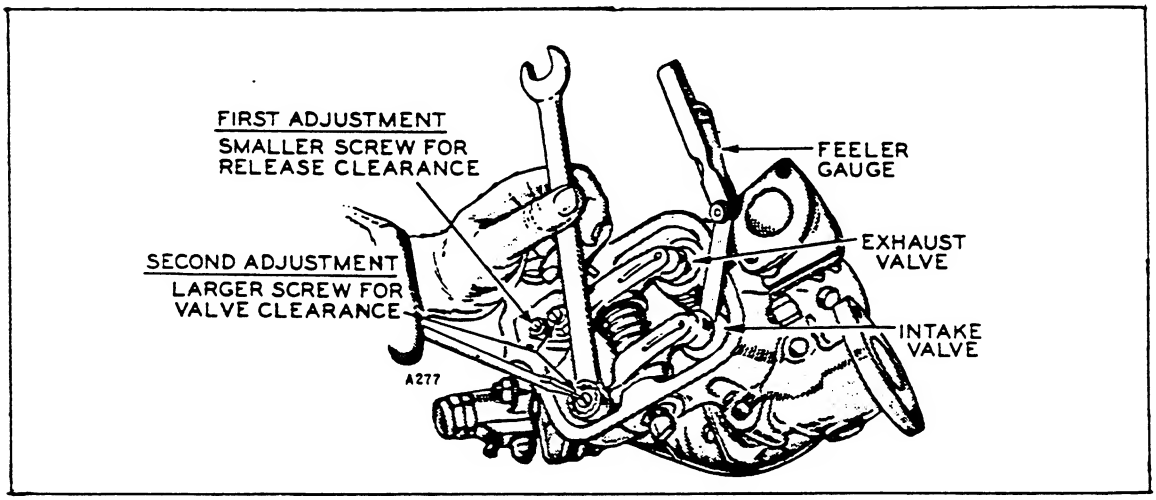


FIG. 26 - ADJUSTING VALVE CLEARANCE

(2) Turn the crankshaft in a clockwise direction until the "TC" mark on the flywheel and the mark or pin on the edge of the flywheel housing timing hole are in alignment on the compression stroke.

(3) The valve nearest the compression release is the exhaust valve. There are two adjustments to be made when correcting the clearance of this valve. Note that the exhaust rocker arm has a compression release adjusting screw and a larger screw for adjusting the valve clearance.

The screw for the compression release must be adjusted first and while the adjusting screw for the exhaust push rod is backed out. A clearance too great, when adjusting this smaller screw, will prevent proper stopping of the engine. A clearance too small will allow the rocker arm to rap against and possibly damage the solenoid plunger used on the remote starting type of plant.

(4) Place the compression release mechanism at disengaged (RUN) position.

(5) Loosen the lock nuts and back out both screws about 3 turns.

(6) Clearance for the release mechanism is 0.027". Place a 0.027" feeler gauge between the exhaust valve stem and the rocker arm and turn the smaller screw inward until it touches the low section of the compression release shaft or plunger, and causes a slight drag on the feeler gauge. Tighten the lock nut and recheck the clearance.

(7) Valve clearance is for cold setting. The push rods are the steel type and valve clearance is 0.015". After completing step (6) place a 0.015" feeler gauge between the exhaust valve stem and the rocker arm and turn the valve clearance adjusting screw in or out with a screw driver as required to correct the clearance. The feeler gauge should have just a slight drag on it when moved back and forth if the clearance is correct. Check the clearance again after tightening the lock nut.

(8) Repeat step (7) for the intake valve.

(9) Reinstall all parts removed. Return the release assembly to engaged (START) position.

TIMING THE INJECTION PUMP TO THE ENGINE

The fuel injection pump is timed to the engine at the factory and should not require retiming at any time. However, should it become necessary, adjustment can be made by means of an adjustable tappet which operates the injection pump.

Timing is 4° BTC (Before Top Center) - PO (Port Opening).

(1) Crank the engine over slowly by hand until the "PO" mark on the flywheel aligns with the indicating pin or mark on the flywheel housing timing hole on the compression stroke. The decompression release lever should be in the "RUN" position so that the exhaust valve is free to operate. Cranking will then become more difficult as the piston comes up on the compression stroke.

(2) Remove the fuel injection pump but do not remove the injection pump adapter.

(3) The timing gauge is wider at one end than the other. Insert the wider end into the opening for the injection pump. The bottom end should just make contact with the top of the tappet screw with both side arms of the gauge resting on the injection pump adapter. As measured by a depth micrometer, the settings should be 1.552" plus or minus 0.002". Remove the tappet to adjust it. Measure and repeat procedure until adjustment is correct.

(4) Install the injection pump on the adapter. Be sure the neoprene seal is in place between the injection pump and the adapter. CAUTION: Just pull the nuts up snug. If they are tightened too much the casting may distort causing a binding condition in the injector pump throttle shaft or pump plunger. Connect the fuel lines. Tighten the fuel line nuts only enough to prevent leakage.

(5) Bleed the fuel system as instructed in Preparation section of this book.

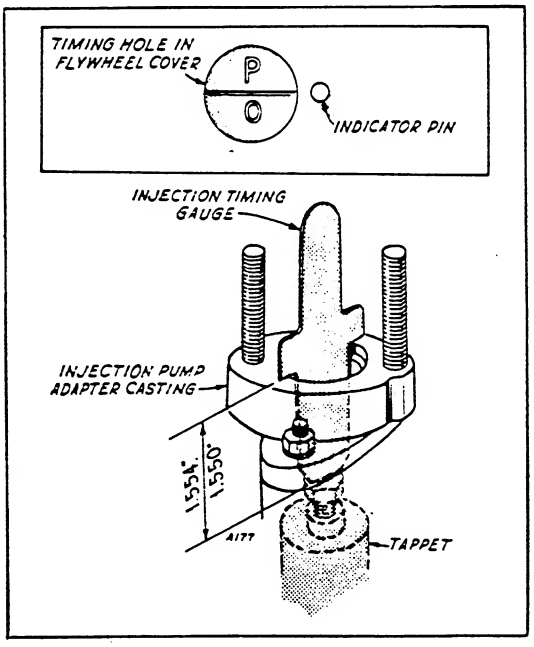


FIG. 27 - TIMING THE INJECTION PUMP TO THE ENGINE

OIL PUMP BY-PASS

The By-Pass is not adjustable and normally requires no service. To determine if high oil pressure is caused by the plunger stuck closed or if low pressure is caused by the plunger stuck open, clean the By-Pass.

Drain the crankcase oil and remove the filter and breather mounting plate to make the By-Pass accessible.

Disassemble as illustrated and clean with diesel fuel or kerosene.

Install By-Pass with cap toward oil reservoir.

Install parts removed and refill crankcase.

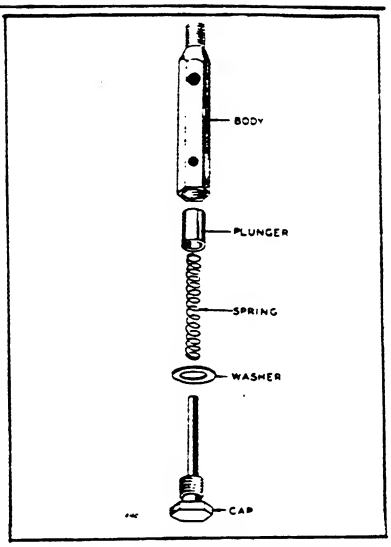


FIG. 28 - OIL PUMP BY-PASS

CRANKCASE BREATHER VALVE

A partial vacuum is created in the engine whenever the engine is running. The work of the crankcase breather valve is to help maintain this partial vacuum and prevent oil leakage. If your engine begins to leak oil, the check valve in the breather cap may be sticking.

Remove the breather cap. Then remove the breather valve from the breather cap and inspect if carefully. If the flexible disc is stuck or does not work freely, soak it in diesel fuel or kerosene for a few minutes. Flex it to permit all the sludge to dissolve. To determine if valve is functioning properly, hold it in place while operating the engine. If not, install a new bre ather valve. Inspect the metal wool in the breather tube. If necessary, clean by slushing the assembly in kerosene or diesel fuel. Install all parts removed making sure the large flat portion of the breather valve is placed down and is next to the gasket.

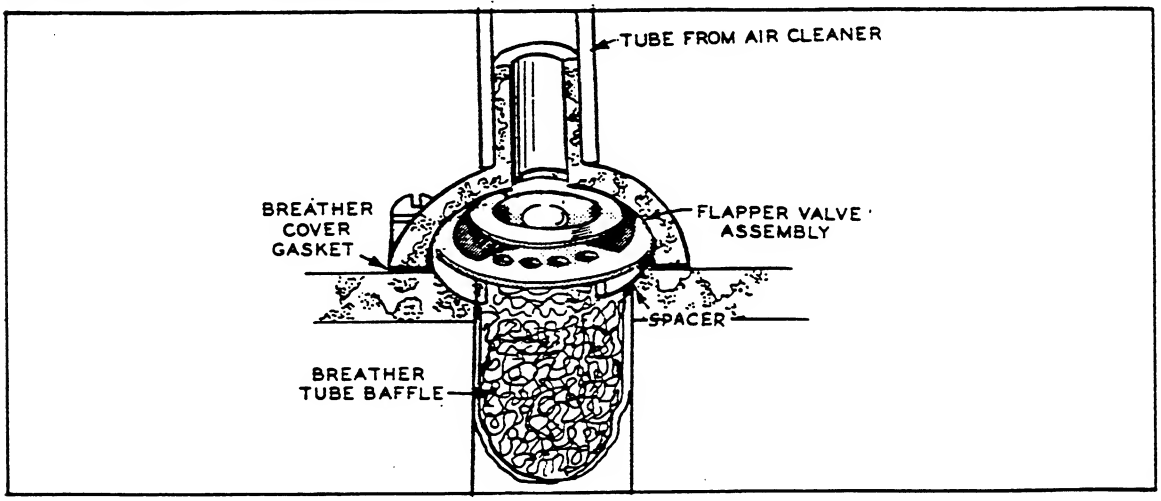


FIG. 28A - SERVICING CRANKCASE BREATHER VALVE

TRANSFER PUMP

A transfer pump of the diaphragm type is used to transfer fuel from the fuel tank through the filters to the injection pump. If fuel does not reach the filter, make the following checks before removing the fuel pump. Check the fuel tank to see that there is enough fuel in it and the shut-off valve is open. Disconnect the fuel line at the transfer pump outlet and work the priming lever on the pump. Fuel should spurt out of the line at the pump. If priming lever does not operate, crank engine one revolution. If there is enough fuel in the tank, the shut-off valve open, and the line between the tank and pump is clear but fuel does not spurt out of the transfer pump outlet, repair or replace the pump. Transfer pump failure is usually due to a leaking diaphragm, a valve or valve gasket; a weak or broken spring; or wear in the driving linkage. A pump repair internal parts kit is available.

Should a new driving link be needed, install it as shown in Fig. 29. DO NOT BEND THE ENDS OF THE LINK AROUND THE ROCKER ARM SHAFT.

FIG. 29 - TRANSFER PUMP LINKAGE

ROCKER ARM REMOVAL

(1) Remove the plate from the top of the cylinder head.

(2) Rotate the engine until the mark or pin on the flywheel housing and the "TC" mark on the flywheel (See Fig. 38) are in alignment on the compression stroke.

(3) Back off the valve adjusting screws.

(4) Remove the pin from the rocker arm shaft.

(5) Use a brass rod and drive the rocker arm shaft out toward the blower housing end of the engine until the "O" ring can be removed from the shaft. Then remove the "O" ring and drive the shaft out toward the other end of the engine. The rocker arms, springs and bushings can then be removed.

ROCKER ARM INSTALLATION

(1) See that the "TC" mark on the flywheel and the marks on the flywheel housing are properly aligned as shown in Fig. 38.

(2) Note that there is a small hole near one end of the rocker arm shaft. There is also a small hole in the rocker arm shaft boss located near the decompression release mechanism. Insert the end of the shaft having the drilled hole into the boss at the generator end of the engine with the hole in the opposite boss. See Fig. 30. Start the shaft by hand being sure the holes remain in alignment.

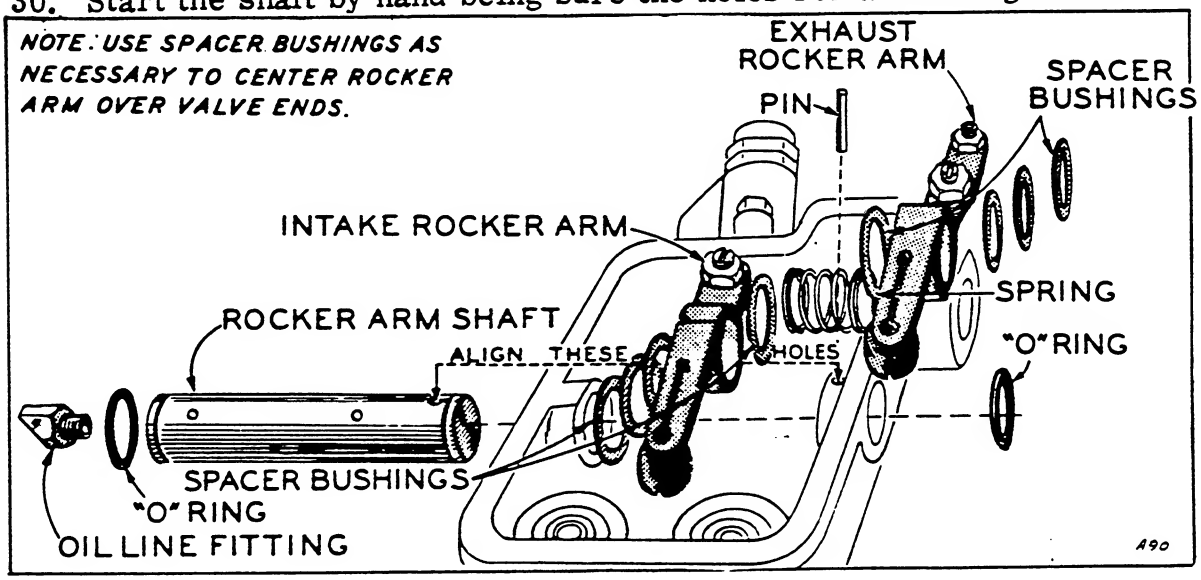


FIG. 30 - ROCKER ARM INSTALLATION

(3) Tap the shaft gently with a lightweight soft faced hammer and drive the shaft through the boss until about 1 inch extends beyond the boss on the inside.

(4) Place bushings on the shaft as necessary to center the rocker arm over the push rod and then the rocker arm having only one adjusting screw. Hold them in place and drive the shaft about half way through the valve box.

(5) Place one bushing on the shaft, then the spacer spring, one more bushing, the other rocker arm and finally bushings as necessary to center the rocker arm over the push rod. These parts can be held in place by inserting a finger through the shaft boss until contact is made with the rocker arm.

(6) Install an "O" ring on the blower end of the shaft and drive the shaft through the boss until the groove is in evidence on the outside of the boss.

(7) Install the "O" ring on the shaft and drive the shaft back into the boss until the pin will fit into the hole in the boss and shaft and drop the pin into place.

(8) Reset the valves and decompression release clearance.

(9) Replace other parts removed to complete the installation.

PUSH RODS

The disassembly and assembly of the rocker arm push rods is self-evident. However, the tappets that operate the push rods will come out more easily if it is known that the tappet has a hole drilled part way down its length into which a bent wire can be inserted and the tappet lifted out.

NOZZLE ADJUSTMENT

A nozzle adjustment is recommended only as a means of correcting a fuel knock resulting from a change in the type of fuel used. Otherwise the original setting of the adjusting screw should not be disturbed. Nozzle pressure set at factory is 1750#. The adjustment is made as follows.

(1) Start the engine and allow it to run until it is thoroughly warmed up.

(2) Remove the top cover Ⓐ from the nozzle holder. See Fig. 31.

(3) Loosen the lock nut Ⓑ just enough to allow the adjusting screw Ⓒ to turn.

(4) Insert a screwdriver into the screwdriver slot of the adjusting screw Ⓒ, hold a wrench on the lock nut Ⓑ and turn the adjusting screw in first one direction and then the other until the knock is least noticeable. CAUTION: Do not turn the adjusting screw more than one turn in either direction from its original position. If nozzle adjusting screw is turned out too far, the burning gases from the combustion chamber may be forced back into the nozzle, causing it to foul and the pintle to stick. If this happens, the nozzle will need to be cleaned or replaced.

(5) Lock the adjusting screw nut Ⓑ securely after making an adjustment. Then replace the cover Ⓐ securely on the nozzle holder being sure the two thin washers are in place under the cover.

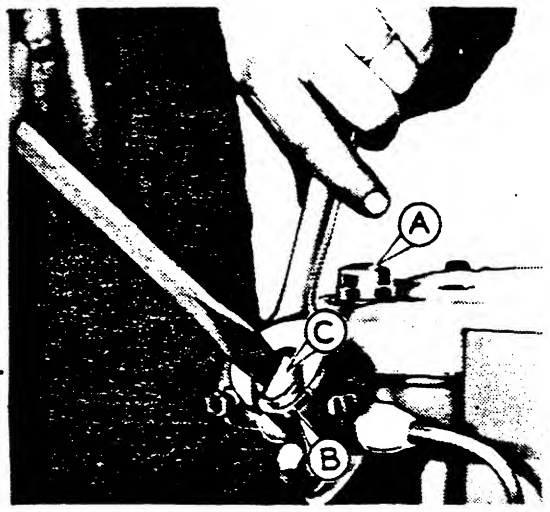


FIG. 31 - NOZZLE ADJUSTMENT

Injection Pumps

ARE HIGHLY PRECISION BUILT

•

CONSULT YOUR DEALER
FOR LATEST EXCHANGE SERVICE OR
REPAIR INFORMATION

•

CLOSE FITS MUST HOLD HIGH PRESSURE

•

FUEL
SUPPLIED TO THE INJECTION PUMP
MUST BE CLEAN !

•

DO NOT TAMPER WITH INJECTION PUMP
UNNECESSARILY

•

CLEAN YOUR HANDS, THEN DIP HANDS
IN CLEAN DIESEL FUEL,
TO AVOID CORROSION OF LAPPED FIT PARTS

ENGINE

GENERAL. - Certain new engines when leaving the factory have a .005" oversize cylinder bore. This oversize is indicaed by the addition of a letter to the engine serial number. For example: Serial No. 48.382425E, the letter E indicating .005" oversize. The piston oversize is stamped on the top of the piston.

Piston and rings are available in various oversizes for rebore jobs. Piston pins are also available in an oversize. Main bearings and connecting rod are available in an underize. See the parts list. Before ordering any repair parts in an oversize and before doing any work on your unit, turn to the parts list and see if the parts needed are available in an oversize or undersize. Parts that are not listed in an oversize or undersize are available only in standard size.

CYLINDER BLOCK INSPECTION. - The innerparts of the engine can be easily inspected after the inspection plate on the air cleaner side of the engine is removed. This is the plate on which the oil filler opening and the breather tube are located. Feel the fits of the working parts. Use a trouble lamp and make a visual inspection of all parts inside the block. If your experience with engines is limited, your dealer or any good local mechanic should be able to help you decide on the need for repairs.

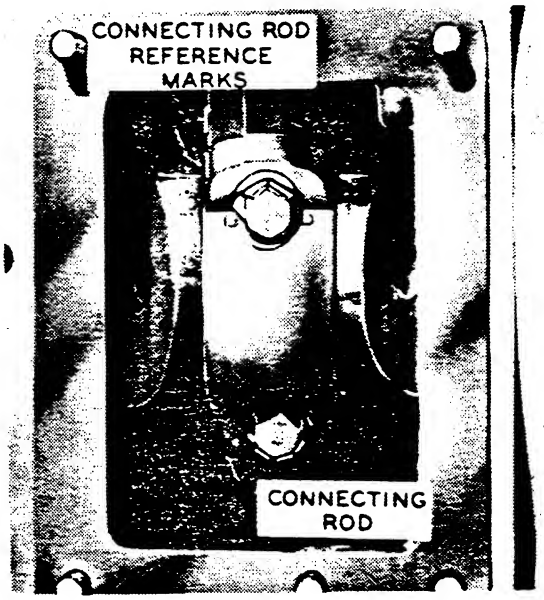


FIG. 32 - CYLINDER BLOCK INSPECTION

Always drain the oil whenever servicing bearings, timing gears, rod, piston or rings. Thoroughly clean the oil pump suction screen and the oil reservoir before reassembling the engine. Refill the crankcase with proper oil before attempting to start the engine.

CYLINDER. - When making major repairs to your unit it is well to have the cylinder measured for wear. This requires the use of a dial gauge. Your dealer should be able to help you or any good local mechanic should be able to check the cylinder. The cylinder bore of a new engine is 3.5015 to 3.5025. If the new engine was bored to oversize originally the bore will be .005" oversize. If the cylinder bore measures more than .005" out of true, the cylinder should be refinished to use the next available oversize piston.

Pistons are available in .010", .020", and .030" oversize. Piston rings are available in .010", .020", and .030" oversize. Use standard rings with .005" oversize pistons.

If the cylinder doesn't need refinishing, it is advisable to remove the ridge from the top of the cylinder before replacing the piston and rings. Also read the following paragraph on PISTON AND PISTON RING SERVICE.

PISTON AND PISTON RING SERVICE. - The piston has three compression rings and two oil control rings. Inspect each ring carefully for fit in piston grooves, for tension, and for seating on the cylinder walls. If there is any doubt as to the condition of the oil piston rings, install new rings. It is advisable to roughen up the cylinder walls before installing new rings. New rings will seat much faster and better. The cylinder walls can be roughened with a wire brush or an abrasive such as emery cloth. Be very careful to remove all abrasive from the engine.

Clean all carbon from the piston, rings, cylinder, cylinder head, valves, gasket surfaces, etc. before installing any parts.

Carefully inspect the piston. If the piston is badly scored or burned, very loose in the cylinder, has badly worn ring grooves or otherwise is not in good condition, install a new piston. A new piston should be installed if the old one is loose on the piston pin and a .002" oversize pin will not correct the fit. Handle the piston carefully to avoid nicking the walls. Any raised surface of this type must be dressed down carefully with a fine stone.

When installing piston rings fit each ring singly to the cylinder from the top. See Fig. 34. The correct ring gap while in the cylinder is between .010" and .015" for all rings except the top compression ring. The gap for this ring is from .010" to .020". Rings usually need some filing at the ends to obtain the right gap. Don't use rings that need a lot of filing at the ends to obtain the right gap as they will not seat properly on the cylinder walls. Install all rings on the piston before installing the piston in the cylinder and coat the cylinder walls with a thin coat of lubricating oil. Rings of the tapered type will be marked "TOP" or identified in some other manner, and this identifying mark must be placed nearer the top of the piston.

Compression rings fit into the three top grooves of the piston, the oil control rings in the 2 bottom grooves. The top compression ring is slightly heavier than the next two compression rings. This ring must be placed in the top groove. By inspecting the rings carefully you can tell which of the three are the thickest. Another means of telling is by the ring gap. The heaviest ring will have a slightly wider gap when free. The correct gap while in the cylinder is .010" to .020" for the top compression ring only.

For the other two compression rings and for the oil control rings the correct gap while in the cylinder is .010" to .015". Space the ring gaps 1/4 of the way around the piston from each other, being sure no ring gap is directly in line with the piston pin. Install the piston (the connecting rod must be assembled to the piston) assembly in the cylinder from the top. Compress each piston ring carefully so that it will enter the cylinder without damaging the ring. Don't use excessive force. Push the piston in until the top is flush with the block. Be sure the reference marks on the connecting rod and cap are on the right hand side and face downward and toward the inspection plate opening and that the rod fits easily into place on the crankshaft journal. See Fig. 32. Coat the crankshaft bearing journal with oil before securing the rod. Apply light oil liberally to the cylinder walls and rings.

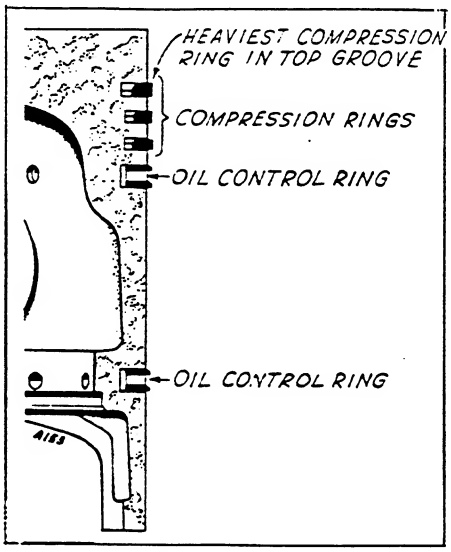


FIG. 33 - LOCATING PISTON RINGS

CAUTION: When installing a piston pin, be careful not to flare the end of pin.

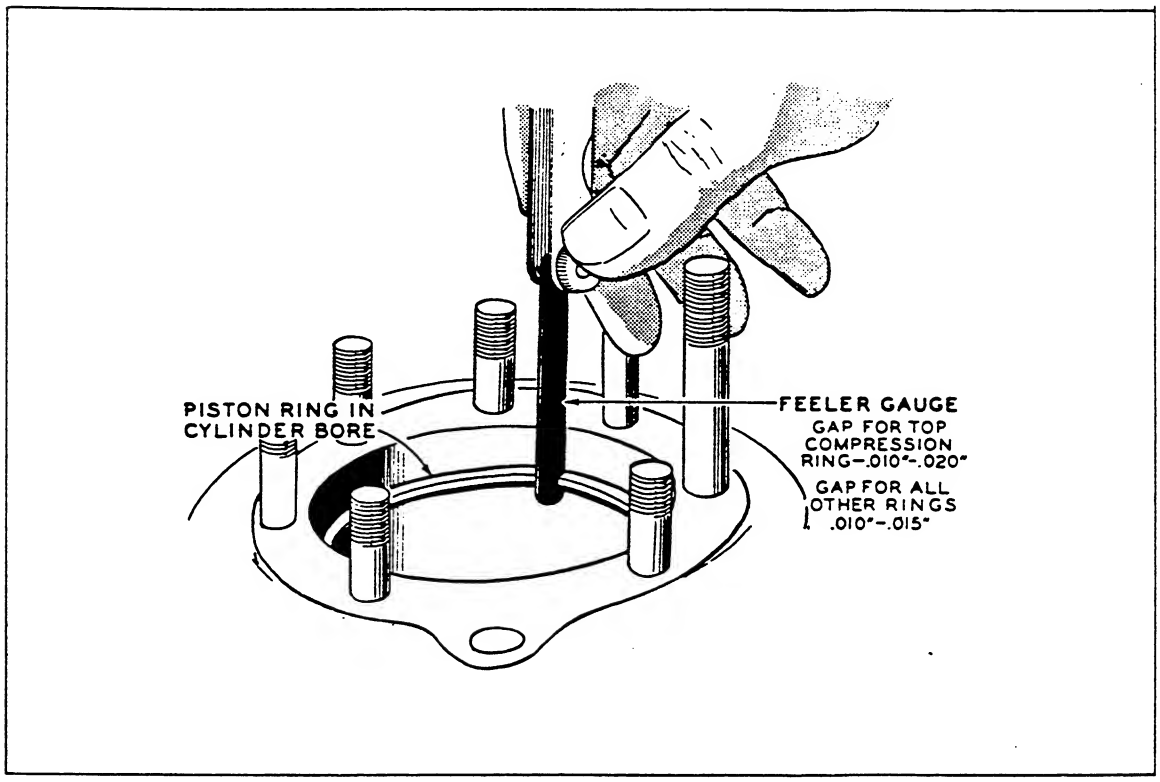


FIG. 34 - PISTON AND PISTON RING SERVICE

CONNECTING ROD. - The connecting rod should be serviced at the same time as the piston or piston rings are serviced as the rod must be removed with the piston. This requires draining the oil from the cylinder block, removing the valve box cover, the cylinder head and the inspection plate from the right side of the cylinder block.

Rods are forged steel with replaceable bushings and bearings. Replace rods with the same material, because a heavier crankshaft is required for proper balance with the forged steel rod than with aluminum alloy rods which were used by the manufacturer in earlier build air cooled models. For fits refer to the TABLE OF CLEARANCES. Bearings and rods are available in undersize and piston pins are available in oversize. See the parts list.

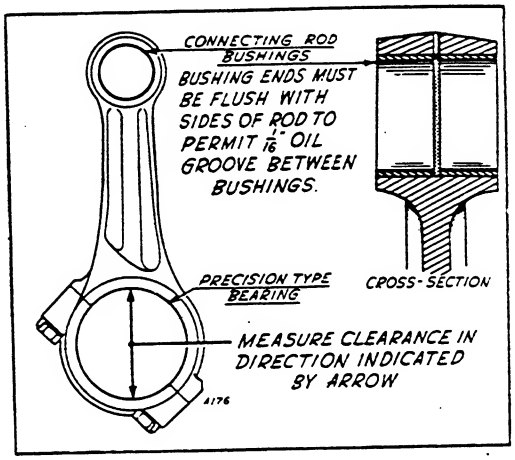


FIG. 35 - CONNECTING ROD SERVICE

On forged steel rods proper clearance is obtained by replacing the pin bushings and the bearings. Install a bushing from each side, flush with the rod, to allow a 1/16" groove for oil passage. The rod bearings are precision type and require no reaming.

Oil the crankshaft journal. Install the rod with the cap toward the inspection hole, and the marks on the rod and cap aligned. Crank the engine by hand to see that the rod is free. If necessary, rap the rod cap sharply with a heavy soft hammer to set the rod square on the journal.

VALVE SERVICE. - The valves are of the overhead type and are located in the head. The valve box cover, air cleaner, oil lines, and the cylinder head must be removed from the engine in order to service the valves. If the cylinder head sticks, rap it sharply with a heavy soft hammer to loosen. Don't use a pry. Remove the rocker arms, valve locks, retainer washer, valve springs, and valves. See Adjustments. Mark each part so that it can be reassembled in its original location.

Clean all carbon from the cylinder, cylinder head, valves, valve seats, valve stems and valve guides. Thoroughly clean the gasket surface of the cylinder head and block. Carefully check all valves. Replace any valves that are badly burned or pitted, have badly worn or warped stems, or that will have a very thin edge when refaced. Inspect the valve guides for wear. Replace guides that are badly worn.

The correct valve FACE angle is 44°. The correct valve SEAT angle is 45°. This 1° interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life.

The valves should not be hand lapped, if at all avoidable, since the sharp contact may be destroyed. This is especially important where stellite faced valves and seats are used. Valve faces should be finished in a machine to 44°. Valve seats should be ground with a 45° stone, and the width of the seat band should be 3/64 to 1/16 of an inch wide.

Remove all grinding compound from engine parts and place each valve in the cylinder head. Check each valve for a tight seat, using an air pressure type testing tool. If such a tool is not available, make pencil marks at intervals across the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat.

Reassemble all parts removed and adjust the valve clearance as given under Adjustments.

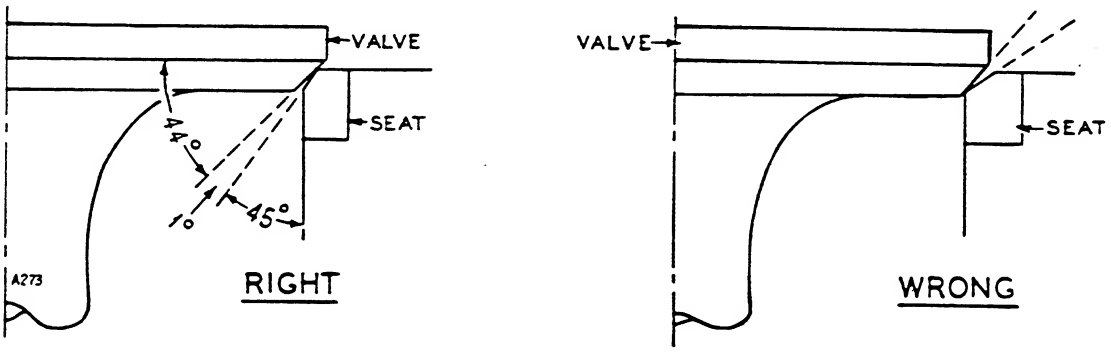


FIG. 36 - VALVE GRINDING

When installing a NEW exhaust valve insert seat, maintain a minimum clearance of 0.030" from the exhaust valve head to the face of cylinder head by grinding the seat.

Use thread compound on studs entering the block water jacket.

When installing a new valve guide on plants prior to serial #498025, it is necessary to chamfer the head to allow for the 1/32" radius under the shoulder of the later design valve guide.

VALVE ADJUSTMENT. - See Adjusting the Valves under ADJUSTMENTS.

FLYWHEEL. - The generator frame assembly, the armature and the generator adapter must be removed to expose the flywheel. Too remove the flywheel, turn until the keyway is downward, place a heavy punch against the crankshaft just above the keyway and hit the punch a hard blow with a heavy hammer. Repeat if necessary. See Fig. 37.

FIG. 37 - REMOVING THE FLYWHEEL

Should the installation of a new flywheel become necessary, the "TC" (top center) and "PO" (port opening) locations should be determined and marked on the flywheel. A dial gauge should be used as shown in Fig. 38. Proceed as follows:

(1) Install the flywheel on the crankshaft and turn the flywheel with rotation until both valves open and close and continue about 1/2 turn until the piston is at the top of the cylinder.

(2) Remove the cylinder head and place the dial gauge (must read 0 to 100 in thousands) as shown in Fig. 38. NOTE: If a dial gauge is not available, make a chalk mark on the flywheel (opposite the pin or housing marks) at the point where the piston just reaches the top of the cylinder. Then continue to turn the flywheel slowly in the same direction until the piston just begins to move downward and make another chalk mark on the flywheel. Make a permanent mark across the flywheel with a scratch awl half way between these two chalk marks. This is the "TC" mark. To find the "PO" mark, measure to the right of the "TC" mark 27/64" for 4^{O} BTC - P.O. timing.

Mark this location on flywheel with a scratch awl.

(3) Turn the flywheel slightly until dial gauge needle indicates piston is exactly on top center. Use a straight edge and a scratch awl to make a mark across the flywheel directly in line with the mark on the flywheel housing. This will be the "TC" mark. Certin units will have a pin to align the mark with, instead of the mark.

(4) Turn the dial gauge until the O mark and the needle on the gauge are directly in line.

(5) Turn the flywheel against rotation until the dial gauge reads 0.0055" on the dial for 4° P.O. Mark the flywheel at the indicator with a straight edge and scratch awl.

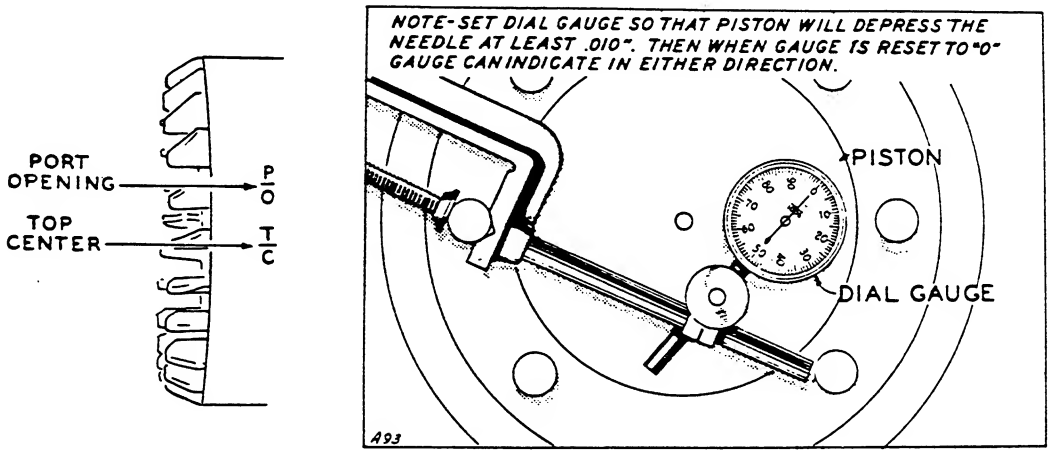


FIG. 38 - INSTALLING A NEW FLYWHEEL

(6) Remove the flywheel and deepen the marks with a chisel. An identifying mark should be made near each mark. The first mark (cranking rotation) will be "PO", the other mark is the "TC" mark.

(7) Install the flywheel (be sure the key is in place) remove the dial gauge, and replace other parts removed.

DECOMPRESSION RELEASE SOLENOID. - On the knurled knob of the solenoid plunger is stamped the voltage (12V or 32V) of the solenoid and whether it is to be used with a grounded (GND or G) or ungrounded (NG) system.

GEARCASE. - The engine gearcase together with the attached cranking chain cover contains water pump parts, governor parts, hand cranking mechanism and the necessary bearings and oil seals. To avoid possible damage to component parts the mechanic should become familiar with the disassembly and reinstallation procedure.

This paragraph contains general statements and cautions to consider before attempting gearcase repair. New bearings for the cranking mechanism require line reaming. A new or reinstalled bushing for the water pump requires reaming. A sleeve type tool for expanding each oil seal for the cranking mechanism is needed. Gaskets are used for gearcase to cylinder block, chain cover to gearcase, water pump body to gearcase, nameplate to water pump body and on the water pump screw plug. One oil seal is used on the governor shaft. Two oil seals are used in the chain cover for the hand cranking mechanism. Two identical seals are used in the water pump, one for oil and the other for water. Refer also to the Subject Heading **WATER PUMP**.

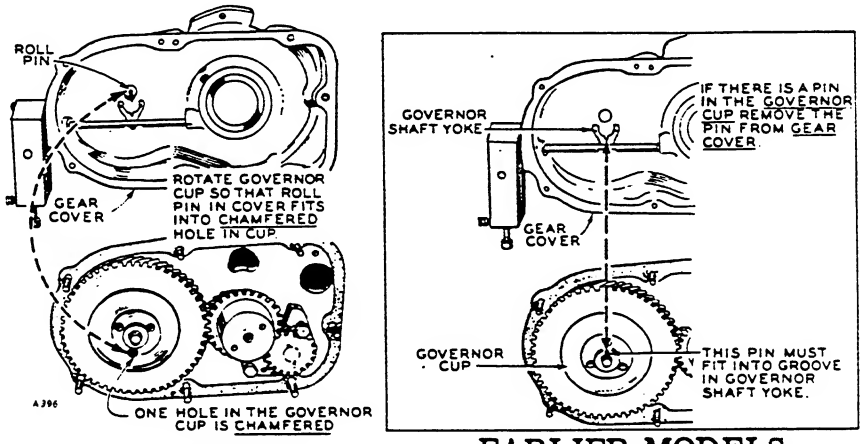
The following details will help when removing and reinstalling the gearcase: Disconnect the governor linkage, water lines and oil lines, Remove attaching hardware. Loosen by rapping with a soft hammer. The chain cover must be removed to expose attaching hardware for the gearcase.

This paragraph pertains to chain cover removal and repair. The pin for the hand crank is a grooved pin. Align it with the holes in the chain cover and tap it out. Removal will be slightly easier toward the direction it was driven in. If a heavier blow is required support the shaft to avoid damage to the seal and bearing. Then insert oil seal expander tools and remove the cover. The oil seals in the cranking chain cover may be easily damaged and difficult to reinstall unless a seal expander tool is used. Two sizes of oil seal expander tools are needed. The expander tool has a thin smooth sleeve which slips over the shaft and inside the seal. Use it when removing and again when reinstalling the cover. Lubricate the surface contacting the seal. Remove oil seals outwardly and press in new seals inwardly. The larger seal should be flush with the inside of the cover. The smaller seal should bottom in the recess of the cover. The installation of new bearings will require reaming.

This paragraph pertains to the hand cranking mechanism. The cranking chain is "3/8 inch pitch single strand American standard, roller type ". There are no precautions for alignment and periodic service should not be necessary. Its only purpose is for hand cranking, however it revolves whenever the engine is operating. Install it completely coupled together by laying it around the two sprocket wheels and installing the wheels simultaneously. Two sleeve type bearings are used for the larger sprocket wheel which is permanently attached to its shaft. The bearing in the gearcase is lubricated from a return line from the cylinder head. The bearing in the chain cover is lubricated by splash. Oil holes must be aligned. New bearings must be line reamed while the gearcase and chain cover are assembled together to a diameter of 1.2525" to 1.2535" . The power take-off shaft is integral with the smaller sprocket wheel and hub. It is held to the crankshaft by a through stud and is driven by two roll pins. A flat metal sealing washer is used between the hub and the crankshaft to prevent oil leakage along the through stud. To remove the power take-off shaft, first remove the chain cover and the through stud nut. Work the shaft off the roll pins which joins it with the crankshaft by alternately tapping opposite sides of the shaft. Avoid damaging the sealing washer.

The governor shaft and arm in operation is shown in the illustration GOVERNOR ADJUSTMENT under SPECIAL ADJUSTMENTS section. On the small inner end of the shaft a needle bearing and a single ball are used. On the outer end of the shaft an oil seal, a needle bearing and a collar are used. When reinstalling the shaft and arm be sure the small ball is in place at the end of the shaft and set the collar on the shaft to permit a shaft end play of .010 to .020 inch.

Begining with Spec B, the governor cup stop pin is located in the gear case cover. Position the governor cup so that the chamfered (smoothest) hole will admit the stop pin located on the gear cover. On models of the earlier design, the governor cup stop pin is located on the governor cup and must fit into the groove in the governor shaft yoke as illustrated. Turn the stop pin until it is at top center.



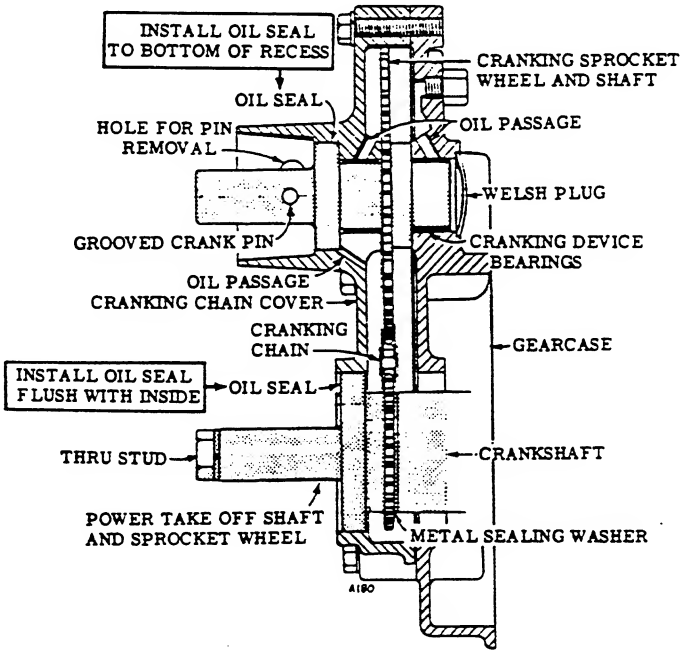


FIG. 39 - INSTALLING THE GEARCASE AND CHAIN COVER

Begining with Spec B, the governor cup pin is located in the gear cover. The pin fits into the polished hole in the governor cup.

WATER PUMP. - The water pump is an impeller type and is very dependable even with salt water operation. The impeller is easily replaceable and it is advisable to have a spare impeller on hand. To install a new impeller, remove the pump nameplate and gasket, grasp the old impeller with a pair of pliers and pull straight out. Avoid damaging the brass body. The water pump body and the gasket on each side are removed by first removing the pump nameplate. Water pump parts are available individually only, unless the gearcase complete is specifically requested.

Unless the need is obvious, further repair should not be attempted until the pump is tested with adequate water and unrestricted lines free of air leaks. A collapsed line, leaky connections, a plugged strainer or restricted suction line, or a suction lift too high may be at fault.

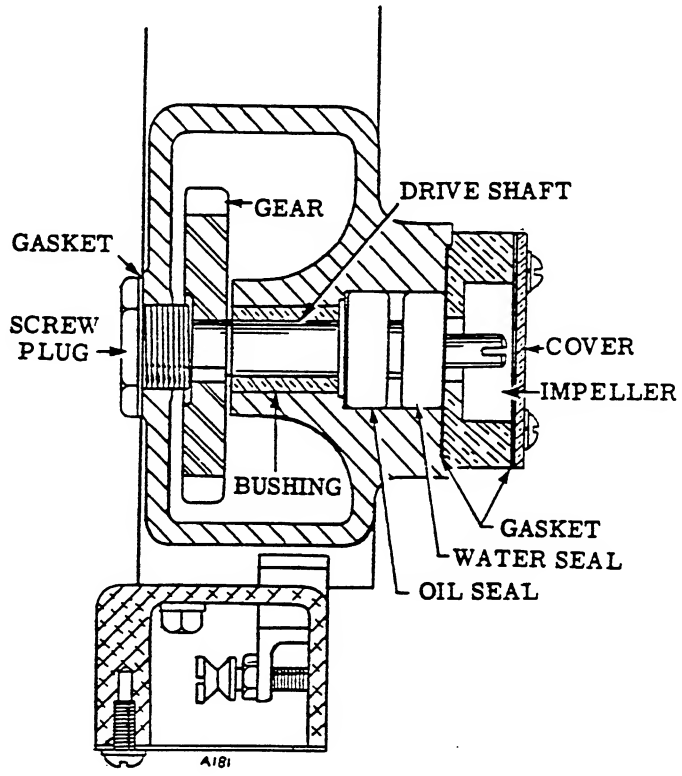


FIG. 39 A - SERVICING THE WATER PUMP

For further water pump repairs such as seals, bushing, gear or drive shaft the gearcase must be removed from the engine. Check for availability of special tools and possibly additional parts required when the gearcase is removed.

To completely disassemble the water pump the following procedure will be helpful. Remove the gearcase from the engine. Remove the water pump nameplate, nameplate gasket, impeller, pump body and body to gearcase gasket. Remove the screw plug and gasket which serves as an end play thrust for the water pump shaft. The drive gear and key will fall free when the pump shaft is pressed or driven out toward the impeller end. (NOTE: While removing the shaft, the bushing will receive the thrust from the gear. Disturbing the bushing will require correcting the end play for the shaft and reaming the bushing. Therefore, if the bushing and seals are not to be removed, then place a support such as a screw driver between the gearcase and the impeller side of the drive gear.)Both water pump seals, should be replaced when either one is faulty. Press or drive the bushing out toward the impeller end, thereby removing the seals.

To reinstall water pump parts this procedure will be helpful. Drive in or press in the bushing from the impeller end with its oil hole aligned until reaching a distance of 3/4" inch from the back side of the gearcase. This should provide a shaft end play of .018 to .044 inch after installing the gear and screw plug. Also the bushing should not contact the oil seal so that the oil return is unrestricted. Ream the bushing before installing seals, to a diameter of .501 to .502 inch giving a clearance of .001 to .003 inch. Oil the shaft, insert it through the bushing, place the key in the gear, place the gear in the gearcase to align with the shaft keyway, support the gear and press or drive the shaft through the gear just flush with the screw plug side which is recessed. Install the screw plug with gasket and check the shaft end play. Avoid damaging the forked end of the shaft. Drive in a new oil seal facing the bushing until it bottoms in the gearcase recess. Drive in a new water seal facing the impeller just flush with the gearcase. Space will remain between the seals to allow any leakage to drain through the drain hole in the gearcase. Avoid scratching oil seal. Don't use sealing compound. Install the pump body, gaskets, impeller and nameplate. Rotate the gear by hand to check for good impeller action yet no binding of other parts.

GOVERNOR CUP. - With the gear cover removed the governor cup can be taken off by removing the snap ring from the camshaft center pin and sliding the cup off. Be sure to catch the ten 9/16" flyballs as they will fall out when the cup is removed.

When installing a new governor cup, tip the plant upward from the front end, place the flyballs in their places and install the governor cup and the snap ring on the center pin. The distance from the snap ring to the governor cup sleeve, when the cup is flush against the flyballs, must be exactly 7/32 of an inch for the governor to operate properly. See Fig. 40. If it is less than 7/32 of an inch, remove the cup and carefully dress down the face of the sleeve until this clearance is obtained. If more than 7/32 of an inch, the camshaft must be removed and the center pin carefully pressed in by means of an arbor press to allow 7/32 of an inch travel. Leave the cup and snap ring on the pin to measure by. Be careful not to bend the center pin as it is not easily replaceable in the field.

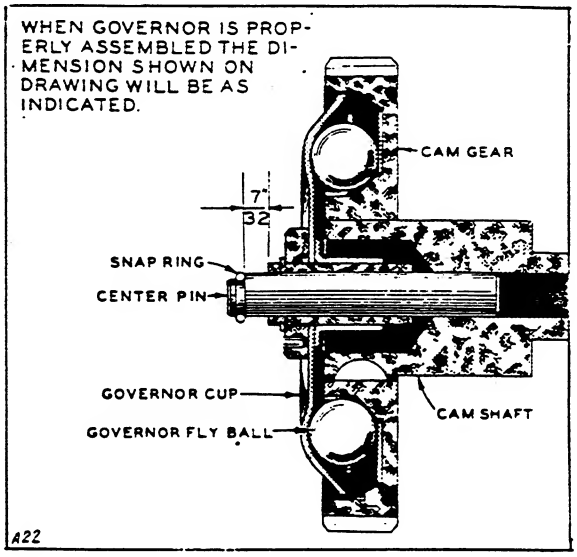


FIG. 40 - GOVERNOR CUP ASSEMBLY

CRANKSHAFT GEAR. - With the gear cover removed the crankshaft gear is easily removed after taking off the snap ring and special washer. The gear is recessed and a conventional gear puller having thin jaws can be used in removing the gear. Apply the puller carefully to avoid damaging the gear if it is to be used again.

When installing a crankshaft gear, use a hollow pipe that will fit over the crankshaft but will not hit the teeth of the gear and drive the gear on to the shoulder on the shaft. Be sure the woodruff key is in place.

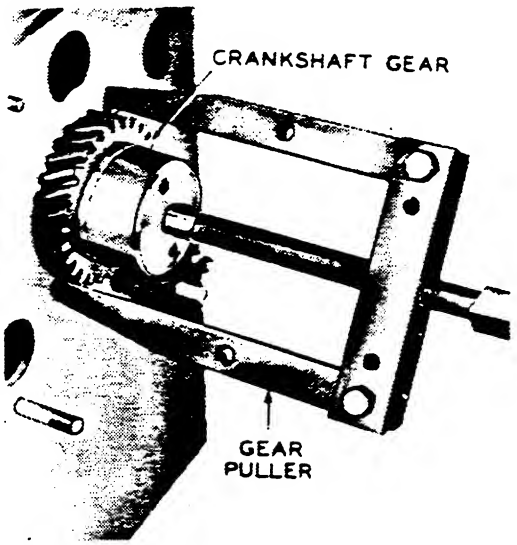


FIG. 41 - REMOVING THE CRANKSHAFT GEAR

Should it become necessary to replace the crankshaft gear, the camshaft gear must also be replaced as these gears are sold only as a matched set.

CAMSHAFT GEAR. - The camshaft and gear should be removed from the engine as an assembly. Before this can be done all parts necessary to expost the gears must be removed from the front of the engine. In addition to the transfer pump, the valve tappets, the

anti-flicker plunger (AC Plants) and the injection pump and tappet must be removed from the engine. If necessary, insert a screwdriver between the block and the gear and apply a little pressure to loosen the camshaft.

If the gear is to be removed from the shaft, remove the snap ring from the center pin and then the governor cup and flyballs. Then place the camshaft and gear in an arbor press and remove the gear. Be very careful not to damage the center pin as it is difficult to replace in the field.

If the camshaft gear must be replaced, the crankshaft gear must also be replaced as they are sold only as a matched set. When pressing the camshaft gear into place on the shaft, be sure the dey is in place and that the gear is straight on the shaft.

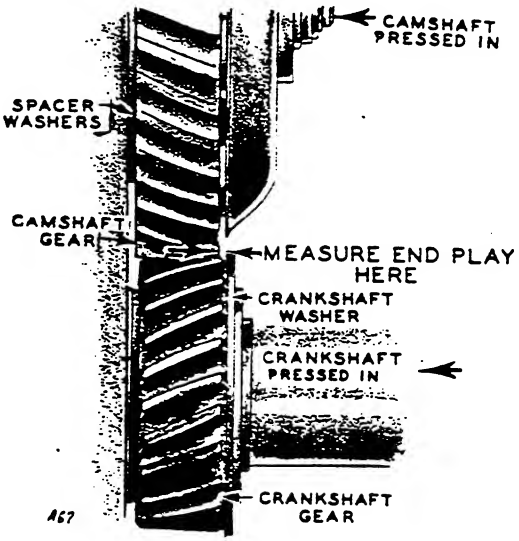


FIG. 42 - CHECKING CRANKSHAFT ENDPLAY

When installing the camshaft and gear, be sure the thrust washer is in place behind the camshaft gear. The thrust washer provides for proper camshaft end
When installing the camshaft and gear, be sure the thrust washer is in place behind the camshaft gear. The thrust washer provides for proper camshaft maximum endplay.

Minimum endplay can easily be determined by pushing in on the camshaft gear and crankshaft gear and inserting a .003" feeler gauge between the camshaft gear and the crankshaft gear washer to check the gap. See the illustration CHECKING CAMSHAFT ENDPLAY. A gap of less than .003" indicates excessive crankshaft endplay.

Always be sure that the timing marks on the gears are aligned whenever gear position has been disturbed.

TIMING GEARS. - The crankshaft gear and the camshaft gear form the timing chain. These gears are matched and are sold only as a set. Should the replacement of either gear become necessary, both gears must be replaced. When installing new timing gears or replacing the old timing gears, the timing marks must be aligned as shown in Fig. 43 or the engine will be out of time.

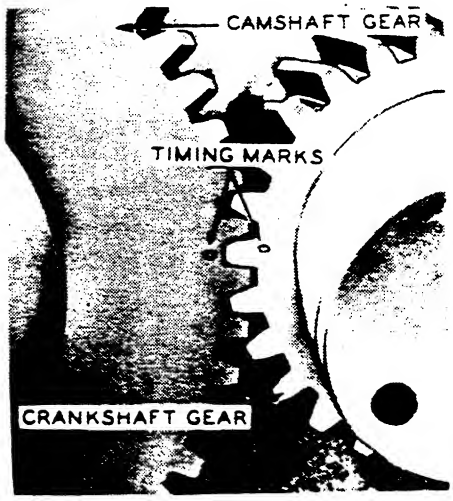


FIG. 43 - TIMING GEAR MARKS

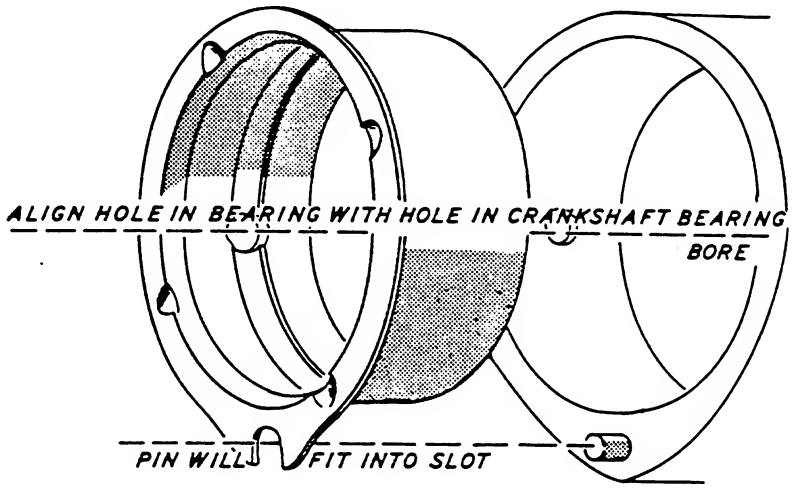
CRANKSHAFT. - The engine must be completely disassembled to remove the crankshaft. Whenever making major repairs on the engine always inspect the drilled passages of the crankshaft and if necessary, clean them to assure proper lubrication of the connecting rods. The bearing journal should also be inspected. If they appear scored and cannot be smoothed out by dressing down, a new crankshaft should be installed or the crankshaft should be ground down to accommodate .020" undersize main bearings and connecting rod bearings. See the parts list.

Crankshaft endplay should be between .010" and .015". This clearance can be checked by inserting proper size feeler gauges between the rear main bearing flange and the crankshaft thrust surface. Clearance can be adjusted by using gaskets as needed behind the bearing plate.

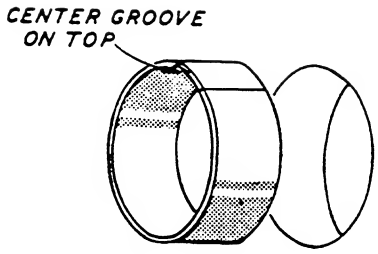
BEARINGS. - Removal of the camshaft or crankshaft bearings require complete disassembly of the engine. Use a press or a suitable drive plug to remove bearings. Drive or press the camshaft bearings from the inside toward the outside of the cylinder block. Drive or press the crankshaft bearings from the outside toward the inside of the cylinder block. Be careful not to damage the bearing boss when removing a bearing. Instructions for the water pump bushing and the hand cranking mechanism bearings appear in foregoing paragraphs.

Crankshaft main bearings are precision type and are available in standard size, .002" undersize for worn engines, and .020" undersize for remachined crankshaft journal. Precision type bearings DO NOT require line reaming. Use the crankshaft as a pilot and with a soft-faced hammer, tap the far end of the crankshaft to drive the crankshaft bearing into place. Align the oil holes for bearing lubrication and align the notch in the bearing flange with the bearing lock pin. A shouldered type bearing lock pin, as is furnished with the new precision type bearing, must be installed on those earlier engines not already having one.

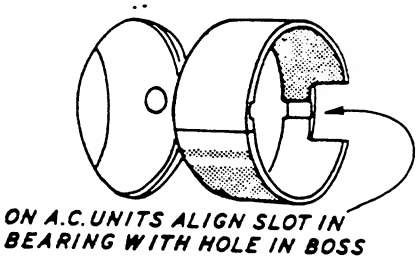
The oil groove of the front camshaft bearing must be centered at the top. The oil hole or slot in the rear camshaft bearing must be aligned with the hole in the bearing boss on alternating current units. Press or drive the front bearing in flush with the bearing boss and the rear bearing in flush with the welch plug groove. Replace the welch plug of the rear camshaft bearing. Coat the bearing journals with light oil before installing the camshaft.



CRANKSHAFT BEARINGS



FRONT CAMSHAFT BEARING



REAR CAMSHAFT BEARING

FIG. 44 - BEARING INSTALLATION

The camshaft bearings must be line bored or line reamed after being installed in the cylinder block. Any reliable machine shop should be able to perform this service. If equipment for line boring or reaming is not available locally, see the dealer from whom you purchased the unit or return it to the factory for repairs. Refer to the Table of Clearances.

OIL SEALS. - The bearing plate must be removed before the oil seal can be removed. Drive the old seal out from the inside toward the outside of the bearing plate.

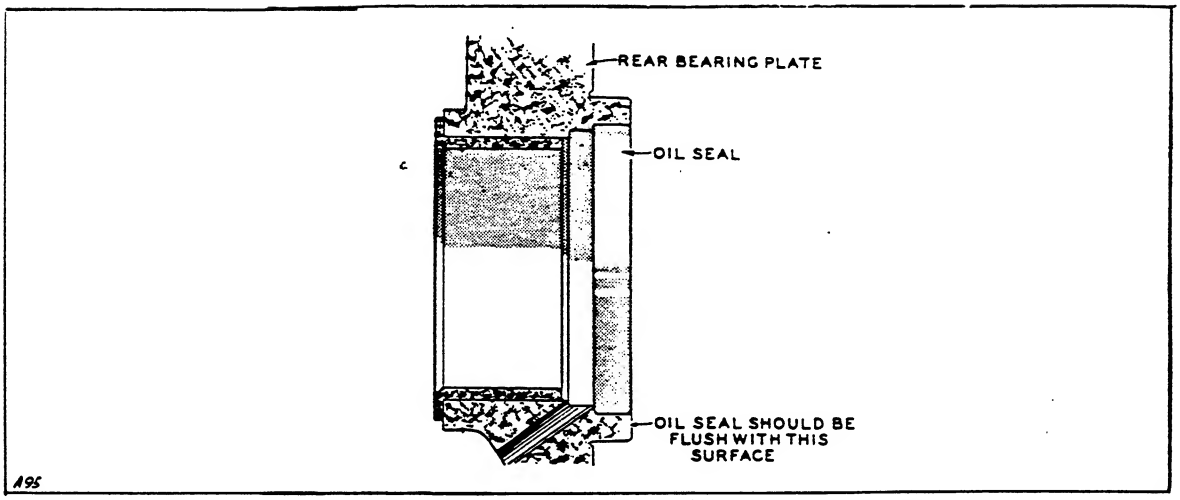


FIG. 45 - OIL SEAL INSTALLATION

When installing the bearing plate oil seal drive the seal into the bearing plate until it is flush with the outer end of the boss. Use a piece of hollow pipe that will fit over the crankshaft and contact the oil seal near the outer edge. Drive the seal in evenly all the way around. Use a piece of shim stock over the keyway to avoid damaging the seal.

Refer also to subjects GEARCASE and WATER PUMP for repair on other seals.

OIL PUMP. - The gear cover and the crankcase inspection plate must be removed before the oil pump can be removed. Remove the pump from the cylinder block as shown in Fig. 46.

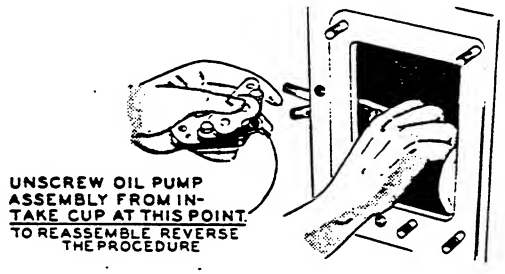


FIG. 46 - OIL PUMP REMOVAL

Check the oil pump thoroughly for worn parts. Should any part need replacing, replace the entire pump assembly as the oil pump is sold only as a complete unit.

Reverse the order of removal when installing the oil pump. Several adjustments may have to be made before the suction cup is in the position shown.

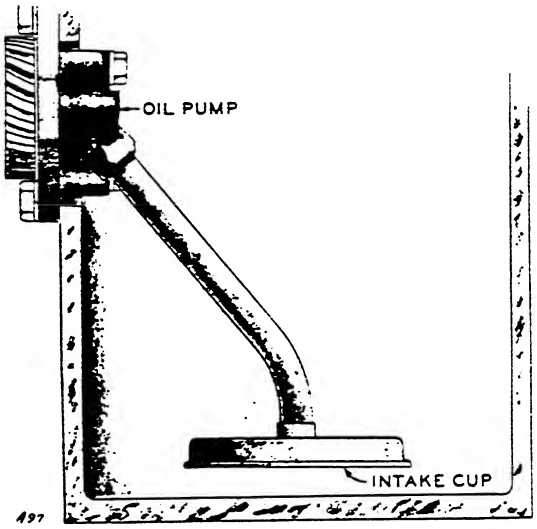


FIG. 47 - OIL PUMP LOCATION IN RESERVOIR

FUEL SYSTEM. - Instructions for servicing various parts of the fuel system are given under **Periodic and Accessory Service**. Several additional service points are covered in the following paragraph.

(1) The fuel system must be leak proof or air leaks may occur and cause trouble. If Permatex or an equivalent thread sealing compound is used on fuel line fittings USE EXTREME CARE THAT NONE ENTERS THE SYSTEM.

(2) It is always good practice to lubricate the transfer pump linkage whenever the pump is removed or whenever a new pump or new linkage is installed.

ROCKER ARM PUSH RODS AND PUSH ROD SHIELDS. - The push rod shields are a drive fit into the collars at the cylinder block and a loose fit into the cylinder head. "O" rings must be installed on the shields after the cylinder head is in place. Turn the crankshaft until the rocker arm lifts and press the "O" rings into place with a blunt tool.

OIL PRESSURE SWITCH (Remote-Starting Plants). - The oil pressure switch makes contact at approximately 5 pounds oil pressure. It serves primarily as an operating switch to close the decompression-release circuit. It is not intended to give adequate plant protection in case of a gradually diminishing oil pressure or too low oil level. Complete failure of oil pressure will open the switch to stop the plant (except if solenoid plunger has been manually locked IN).

For ungrounded systems, since the switch used is not internally grounded, the second terminal is for completing the circuit. Make connections electrically secure. A switch failed closed will prevent normal cranking. A switch failed open will prevent compression.

HIGH WATER TEMPERATURE CUT-OFF SWITCH. - The High Water Temperature Cut-Off Switch is in the Decompression Release Circuit. This thermostatic switch is a safty device for plant protection against dangerously high water (coolant) temperature. It operates to short out the Decompression Release Relay and thereby stop the plant. The switch is calibrated to make contact at 203°F. (plus or minus 5 degrees).

The switch for the ac plant and the dual purpose plant is internally grounded and has one terminal. The switch for the 32 volt battery charging plant is used with an ungrounded system, and since it is not internally grounded, has a second terminal for completing the circuit. Make connections electrically secure.

THERMOSTAT AND COOLANT SYSTEM. - Most details pertaining to the coolant system are covered under INSTALLATION. Before entering the block, coolant water is fed through the exhaust outlet casting which is designed as a heat exchanger for cooling the exhaust and slightly warming the coolant water. The warming of the coolant water helps protect the hot engine cylinder block.

The thermostat in the engine water outlet opens at approximately 160°F. Observe if the thermostat has a TOP marking and install it accordingly. A by-pass within the thermostat housing casting is used in conjunction with the thermostat. Therefore, water leaving the engine outlet does not indicate the thermostat is open. Inspect and clean the by-pass hole in the cylinder head and through the outlet casting, whenever the thermostat is serviced. The thermostat operates to maintain efficient operating temperature.

NOZZLE FAILURE. - Nozzle failure may be due to foreign material causing the pintle to become jammed. Check all other possible causes of engine trouble first. With hands cleaned and dipped in clean diesel fuel, remove nozzle nut from combustion chamber end of nozzle holder. Inspect nozzle pintle. If jammed or scored, install a new nozzle. If fouled with carbon, clean and continue in service, using cleaning tool set available through the dealer.

GASKET. - Always use new gaskets when replacing any part that requires a gasket. Thoroughly clean the surface that the gasket contacts before installing the gasket. Gaskets are listed singly in the parts list, also in kit form under SERVICE KITS.

ASSEMBLY TORQUES

Assembly torques as given here require the use of a torque indicating wrench. These assembly torques will assure proper tightness without danger of stripping the threads. If a torque wrench is not available, you will have to estimate the degree of tightness for the stud, nut or screw being installed and tighten accordingly. Be careful not to strip the threads. Check all studs, nuts, and screws often. Tighten as needed to prevent them from working loose.

Use sealing compound around studs which enter the block water jacket.

CYLINDER HEAD STUDS AND NUTS. - 45 to 50 pounds feet torque.
CONNECTING ROD BOLTS(with locks). - 27 to 30 pounds feet torque.
CONNECTING ROD PLACE BOLTS(no locks). - 40 to 45 lbs. feet torque.
ARMATURE THRU STUD AND NUT. - 40 to 45 pounds feet torque.
NOZZLE HOLDER STUDS. - 15 to 16 pounds feet torque.
BEARING PLATE STUDS. - 18 to 20 pounds feet torque.
BEARING PLATE PLACE BOLT. - 35 to 40 pounds feet torque.
FLYWHEEL. - 40 to 45 pounds feet torque.

Tighten other studs, nuts and screws just enough to assure tightness.

TABLE OF CLEARANCES

	MINIMUM		MAXIMUM
Valve Tappet Clearance - Cold	.015"		
Valve FACE Angle	44°		
Valve SEAT Angle	45°		
Valve Stem Clearance in Guide	.003"		.0045"
Valve Seat Width	3/64"		1/16"
Crankshaft Main Bearing Clearance	.0025"		.004"
Crankshaft Rod Journal - Standard Size	2.3745"		2.3750"
Crankshaft Endplay	.010"		.015"
Camshaft Bearing Clearance	.001"		.003"
Camshaft Endplay	.003"		
Connecting Rod Bearing Clearance - Forged Steel Rod with Precision Type Bearings (Measured parallel with length of rod)	.001"		.003"
Connecting Rod Endplay	.002"		.011"
Timing Gear Backlash	.001"		.006"
Oil Pump Gear Backlash	.003"		.005"
Piston Clearance in Cylinder (at bottom of skirt)	.0035"		.0055"
Piston Pin Clearance in Piston - Tap Fit	.0000"		.0003"
Piston Pin Clearance in Rod (forged steel rod with bushings)	.0002"		.0007"
Top Compression Ring Gap in Cylinder	.010"		.020"
Other Compression Rings and Oil Ring Gap in Cylinder	.010"		.015"
Injection Pump Timing - 4° BTC - P.O.	1.552"	±	.002"
Anti-Flicker Breaker Point Gap (AC Units Only)	.025"		
Compression Release Adjusting Screw - With Release at Running Position	.027"		
Exhaust Valve Head to Face of Cylinder Head (Maintain by grinding new seat)	.030"		
Cylinder Bore - Standard Size	3.5015"		3.5025"
Crankshaft Main Bearing Journal - Std. Size.	2.7495"		2.7500"

GENERATOR

The generator normally needs little care other than proper lubrication of the armature ball bearing and a periodic check of the brushes, commutator and collector rings (a-c plants only). If a major repair job on the generator should become necessary, have the equipment checked by a competent electrician, one who is thoroughly familiar with the operation of electric generating equipment. The generator should be disassembled in the following manner and all leads that must be disconnected should be tagged and marked before removal.

(1) Disconnect the battery to prevent accidental starting of the unit.

(2) Remove the band from the end bell and lift all brushes into their holders. Pull each brush into its holder until the spring rests against the side of the brush to hold it in place.

(3) Remove the cap nuts at the outboard end of the end bell, place a pinch bar against the boss on the generator adapter and pry against the generator frame until loose. Alternate from one adapter boss to the other if necessary.

(4) Carefully slide the frame assembly (includes frame, coils, end bell and brush rig) off the studs, being careful not to let it rest or drag on the armature. Hold the end bell along with the frame as the end bell is loose on the frame.

(5) If the armature is to be removed, black the armature nut out 3 or 4 turns and hit the nut an endwise blow with a heavy soft hammer. Should the armature fail to come loose by this method, place a piece of brass rod against the armature shaft at the top, between the commutator (collector rings on a-c plants) and the bearing, and strike a sharp downward blow on the rod with a heavy soft hammer. Turn the armature over 1/2 turn if necessary to repeat.

(6) Should removal of the brush rig become necessary, proceed as follows: To remove the brush rig from units having an end bell of the type shown in Fig. 48A, disconnect all leads necessary (be sure they are marked) remove the end bell from the frame assembly, remove the four cap screws that mount the brush rig ring and remove the brush rig.

To remove the brush rig from units having an end bell of the type shown in Fig. 48B, disconnect all leads necessary (be sure they are marked), remove the end bell from the frame assembly, remove the four screws in the bearing hub at the outboard end of the end bell and remove the brush rig.

SERVICING THE GENERATOR

BRUSHES. - Keep a close check on the generator brushes. Brushes worn to 5/8" should be replaced. If brushes appear to wear rapidly check the commutator and collector rings (a-c plants only). If they become pitted or rough or if the mica between the commutator bars comes in contact with the brushes, brush wear will be rapid. An improperly adjusted brush rig will also cause rapid brush wear. A sticking start relay, solenoid, or switch can also cause rapid brush wear due to the unit continuing to crank although the engine may be running. Each of these causes of brush wear are treated in separate paragraphs.

NEUTRAL BRUSH POSITION. - Neutral brush position is important. If the brush rig is not properly adjusted so that there is no arcing of the brushes (neutral brush position), brush wear will be rapid, voltage and current will be unsteady and the generator may overheat.

Markings were made at the factory to indicate the netural brush position. These markings are shown in Fig. 48. Two different methods of mounting the brush rig on these plants are used and both are shown in the illustration. Select the one that applies to your plant and proceed as follows:

If the brush rig is mounted as shown in Fig. 48A, the location of the "neutral brush position" mark is indicated by yellow paint on the brush rig ring near one of the mounting screws. This mark should be flush with the brush rig mounting boss as shown in the illustration. If it is not, loosen the brush rig mounting screws and shift the whole brush rig assembly as needed to align the mark. Tigthen the mounting screws securely after making an adjustment.

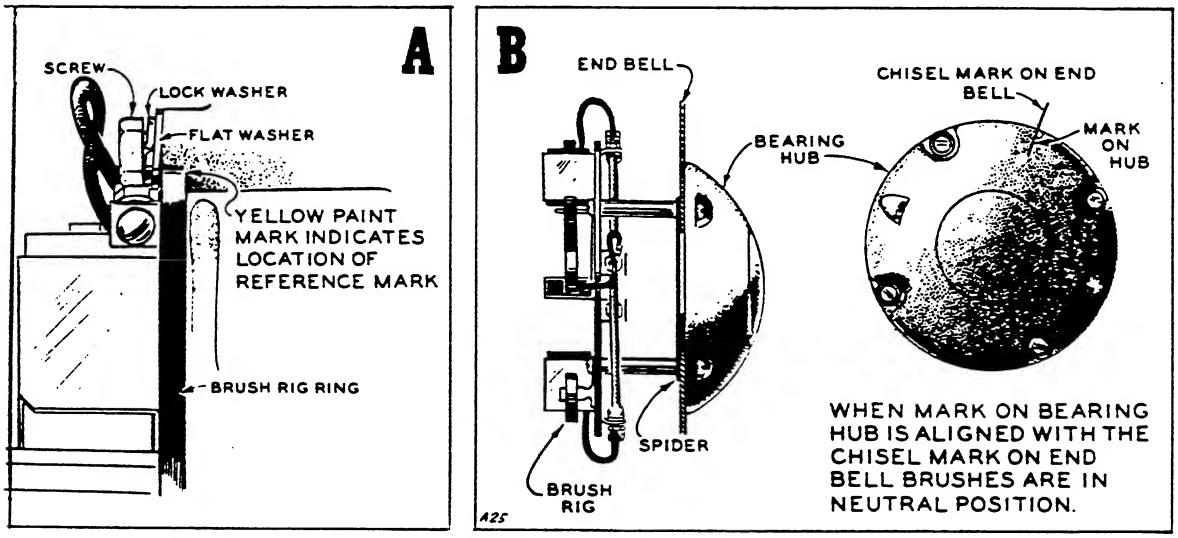


FIG. 48 - NEUTRAL BRUSH POSITION MARKINGS

If the brush rig is mounted as shown in Fig. 48B, the "neutral brush position" markings are located on the bearing hub and the end bell. These marks should be in alignment. If they are not, loosen the four screws in the bearing hub and shift the hub and brush rig as needed to align the marks. Tighten the mounting screws securely after making an adjustment.

If a new brush rig or armature is installed, the "neutral brush position" must be relocated and remarked. Full instructions for performing this service are included with all new armatures and brush rigs.

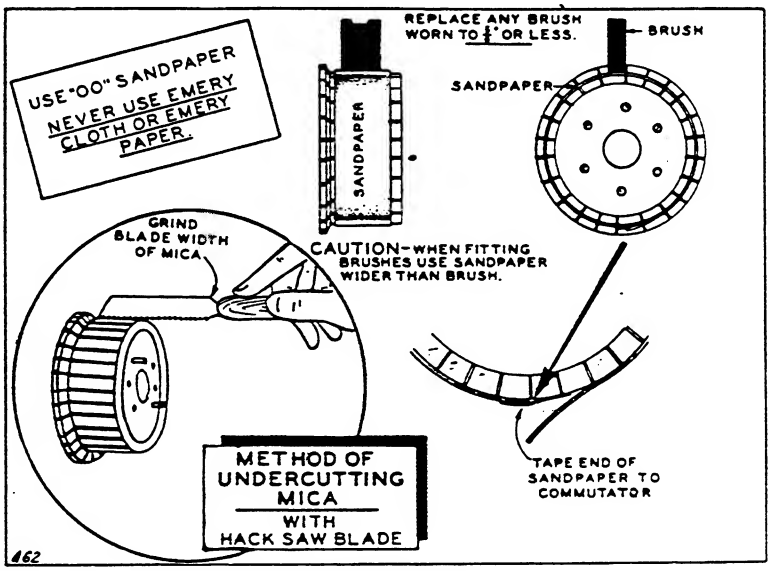


FIG. 49 - CARE OF COMMUTATOR AND BRUSHES

COMMUTATOR. - The commutator bars wear down with usage so that the mica between them must be undercut. This should be done when ever the mica on any part of the commutator touches the brushes. A suitable undercutting tool can be made from a used hack saw blade. Use it as shown in Fig. 49. Avoid injury to the surfaces of the commutator bars. Leave no burrs along the edges of the bars. The mica must also be undercut whenever the commutator is refinished.

COLLECTOR RINGS (AC Plants Only). - If the collector rings become grooved or out of round, or the brush surface becomes pitted or rough so that good brush contact cannot be maintained, remove the armature and refinish the collector rings in a lathe. If the commutator appears to be in need of it, refinish it at the same time.

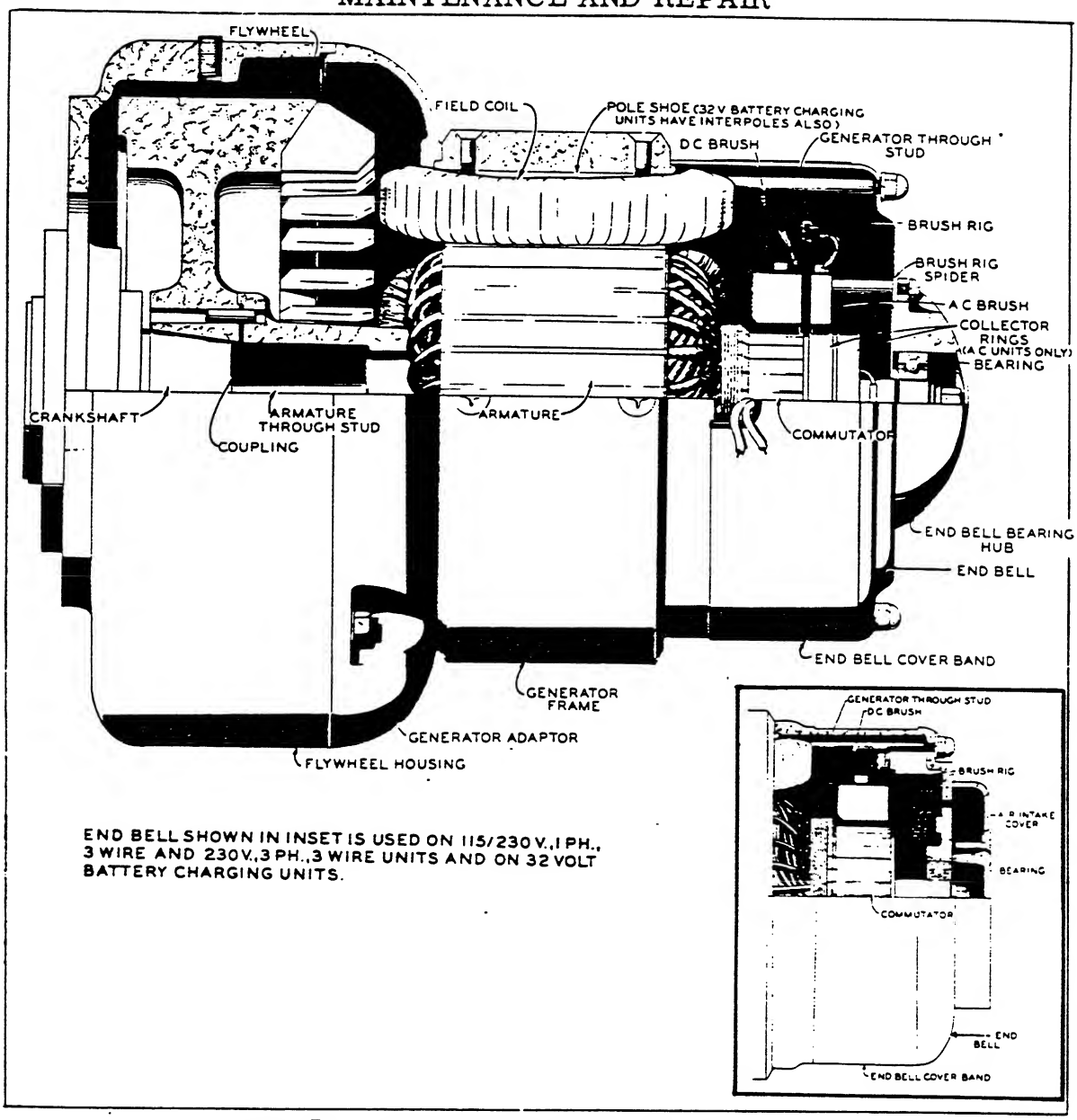


FIG. 50 - CUTAWAY VIEW OF GENERATOR

ARMATURE INSTALLATION. - When installing the armature, the runout at the bearing end should not exceed .012". This runout can be checked by one of the methods shown in Fig. 51. Excessive runout may be caused by a nick or foreign matter on the flange surfaces. Take any steps necessary to correct.

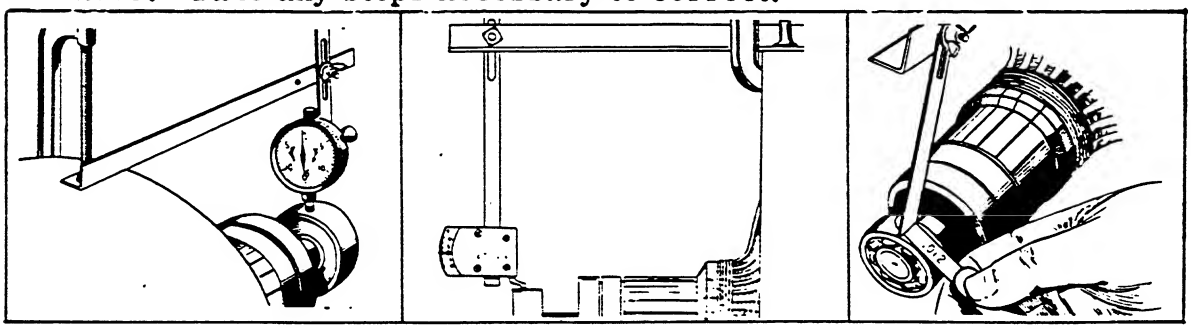


FIG. 51 - CHECKING GENERATOR BEARING RUNOUT

TEST WINDINGS. - A test lamp set and an armature growler are required for the various tests. Before making any test, lift all brushes into their holders and disconnect the load circuit wires from the plant. If the armature tests defective, replace the entire coil assembly unless the trouble is in one of the external leads. Then it can be repaired as the nature of the trouble requires.

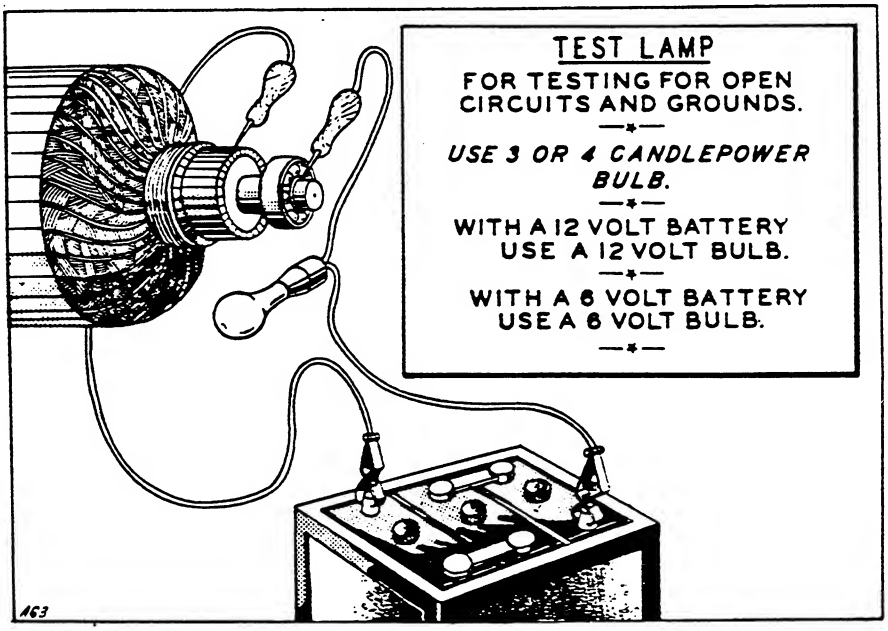


FIG. 52 - TEST LAMP SET

TESTING ARMATURE WINDINGS FOR OPEN OR SHORT CIRCUITS.- This test requires the use of an armature growler. The armature assembly must be removed from the plant. Then follow the instructions given by the manufacturer of the armature growler.

TESTING ARMATURE WINDINGS FOR GROUNDS. - Use a test lamp set. Touch one test prod to the armature shaft and the other to the commutator. If it's an ac plant, touch each collector ring in turn after checking the commutator. Be sure the test prods make good contact. If the lamp lights, the armature is grounded.

TESTING FIELD WINDINGS. - Use a test lamp set for all tests except a short circuit. The Battery Charging units are of the shunt wound type with interpoles and series field. There are actually three separate windings to test. The alternating current units are saturated shunt wound with a series field in addition for cranking and battery charging purposes. There are two sets of windings to test on these units. Disconnect all external leads of the coil assembly from the brush rig before testing. Tag and mark each lead before disconnecting it to assure proper connections when reassembling.

TESTING FIELD WINDINGS FOR OPEN CIRCUIT. - To test a coil winding for an open circuit, disconnect its external leads and touch one test prod to the terminal of one coil lead and the other test prod to each of the other leads of that winding . If the lamp does not light the winding being tested is open. If the fault lies in a connection between coils or in a coil lead, the trouble can be repaired. If the trouble is inside the coil proper, replace the entire coil assembly.

TESTING FIELD WINDINGS FOR SHORT CIRCUIT. - If one coil is short circuited it will run cooler than the others and it may be possible to locate the short-circuited coil by placing your hand on the generator frame at each of the poleshoe positions and noting at which poleshoe position the frame is cooler than normal. A more definite test is a comparative resistance test or a comparative voltage drop test. If the coil windings are short-circuited, replace the entire coil assembly.

FIELD COIL INSTALLATION. - The generator frame assembly must be removed from the unit before the field coils can be removed from the poleshoes. Tag and mark all external leads before disconnecting to assure correct connections when reassembling. When removing the poleshoes and coils, be sure to keep the shims used under each poleshoe together to assure correct air gap when installing the coil assembly and poleshoes.

When installing a coil assembly, be sure it is in the original position in the frame. If it is not, the coil leads cannot be properly connected. Insert the poleshoe into the coil (be sure the poleshoe shims are in place) and secure the poleshoe to the frame. Tighten the poleshoe mounting screws securely. If they should work loose serious damage to the generator would result. Install each of the other coils and poleshoes in the same manner. Connect the external lead as marked on the tags. If a new coil assembly is being installed, make the connections the same as marked for the old coil assembly.

POLESHOE INSTALLATION. - Follow the instructions given for FIELD COIL INSTALLATION

CONTROLS

If any of the control panel equipment fails to function properly, replace the defective part with a new part of the same kind rather than try to repair the old part. No attempt should be made to repair such parts as meters, fuses, switches, relays or receptacles. Check all electrical connections and contacts whenever servicing control equipment.

Always disconnect the battery before servicing any control parts to avoid accidentally starting the unit. When removing any control part, tag and mark the connection point of each lead that has to be removed to assure correct connections when reassembling.

The wiring diagrams which appear in the back of this manual are for standard model plants. If the plant has special electrical or control features, refer to the special wiring diagram for that plant.

PROTECT

YOUR INVESTMENT !

PREPARE IDLE PLANTS FOR STORAGE. SEE "PREPARING UNITS FOR STORAGE".

FREQUENT INTERVALS OF OPERATION UNDER FULL LOAD IS RECOMMENDED FOR BETTER OPERATION OF THE PLANT NORMALLY BEING RUN UNDER ONLY LIGHT LOAD. REFER TO "STOPPING THE PLANT".

POSSIBLE CAUSE	REMEDY
ENGINE CRANKS TOO STIFFLY	
Load not disconnected from unit.	Disconnect load from unit when starting.
Too heavy oil in crankcase.	Use only recommended grades.
Engine stuck.	Disassemble and repair.
Compression release in running position. NOTE: Engine may not even turn over.	Compression release must be at start position when starting the engine.
ENGINE WILL NOT START WHEN CRANKED	
Air in fuel system.	Bleed the fuel system.
Lack of fuel or faulty injection caused by dirty fuel.	Keep fuel tank filled. Keep fuel clean. Use only recommended fuels.
Clogged fuel filter.	Keep supplies of fuel clean. Replace fuel filter element.
Poor fuel.	Use only recommended grades.
Poor compression due to leaky gasket, loose head, worn valves or piston rings.	Tighten cylinder head. Replace cylinder head gasket if necessary. Grind valves, replace if necessary.
Wrong injection pump timing.	Check the injection pump timing.
ENGINE CRANKS SLOWLY OR WILL NOT CRANK	
Defective or discharged battery.	Replace or recharge battery.
Loose connections or broken wire in generator circuit.	Tighten loose connections. Replace terminals or wire where necessary.
Corroded battery terminals.	Clean corroded terminals. Replace cable if necessary.
Generator brushes worn excessively or making poor contact.	Replace brushes. See that brushes make good contact.
Short circuit in generator or load circuit.	Repair as needed.

POSSIBLE CAUSE	REMEDY
ENGINE RUNS BUT VOLTAGE DOES NOT BUILD UP	
Poor brush contact.	See that brushes seat well on commutator and collector rings (where used), are free in holders, are not worn shorter than 5/8 in ch and have good spring tension.
Open circuit, short circuit or ground in generator.	Check and repair or replace as described under GENERATOR in the Maintenance and Repair section.
VOLTAGE UNSTEADY BUT ENGINE NOT MISFIRING	
Speed too low.	Adjust governor to correct speed.
Injection pump fuel metering shaft not properly adjusted.	Adjust as instructed under SPECIAL ADJUSTMENTS.
Poor commutation or brush contact.	Refinish commutator or undercut mica if necessary. See that brushes seat well on commutator and collector rings (where used), are free in holders, are not worn shorter than 5/8" and have good spring tension.
Loose connections.	Tighten connections.
GENERATOR OVERHEATING	
Short in load circuit.	Correct short circuit.
Generator overloaded.	Reduce load.
Improper brush rig position.	Adjust to "neutral" position.
ENGINE OVERHEATING	
Improper lubrication.	See Low Oil Pressure.
Poor ventilation.	Provide ample ventilation at all times.
Dirty or oily cooling surfaces.	Keep the engine clean.
Retarded injection timing.	Retime.
Generator overloaded.	Reduce load.

POSSIBLE CAUSE	REMEDY
VOLTAGE DROPS UNDER HEAVY LOAD	
Engine lacks power.	See Engine Misfires at Heavy Loads.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings - as needed.
Faulty injection.	Check fuel system. Dirty fuel is main cause. Use only recommended fuels.
Dirty air cleaner.	Clean. Refill with proper oil.
Dirty fuel filter.	Keep fuel clean. Replace element in fuel filter.
Restricted exhaust line.	Clean or increase the size.
ENGINE MISFIRES AT LIGHT LOAD	
Faulty injection.	Dirty fuel is main cause. Use only recommended fuels.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings-as needed.
Poor grade of fuel.	Use only recommended fuels.
ENGINE MISFIRES AT HEAVY LOADS	
Faulty ignition.	Dirty fuel is main cause. Use only recommended fuels.
Dirty air cleaner.	Clean. Refill with proper oil.
Dirty fuel filter.	Keep fuel clean. Replace element in fuel filter.
ENGINE MISFIRES AT ALL LOADS.	
Leaky valves.	Refer to VALVE SERVICE under Maintenance and Repair.
Broken valve spring.	Replace.
Defective or dirty nozzle.	Install new nozzle.

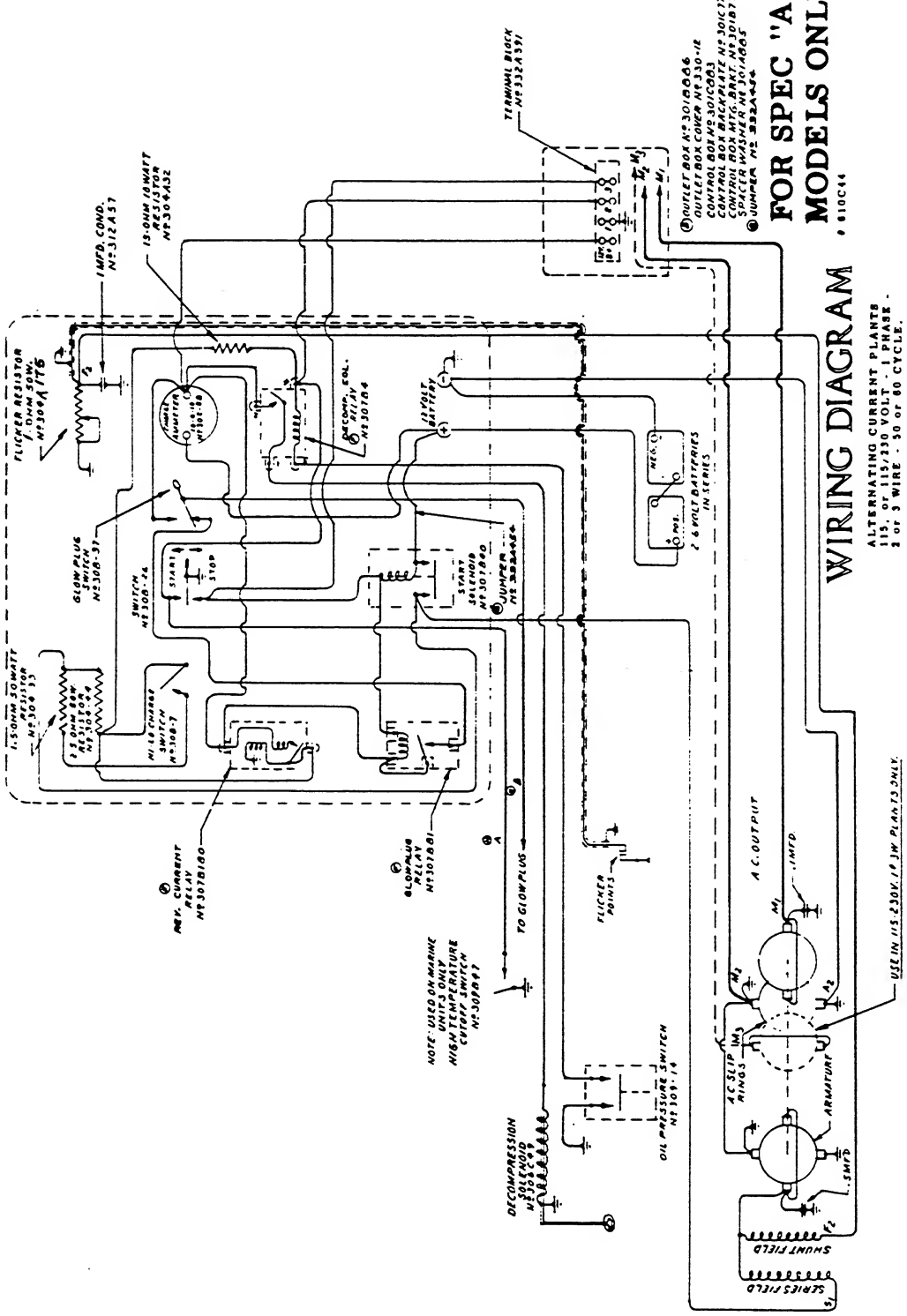
POSSIBLE CAUSE	REMEDY
LOW OIL PRESSURE	
Defective oil pressure gauge.	Replace.
Oil too light or oil badly diluted, caused by leaking transfer pump diaphragm.	Drain. Refill with proper oil. Repair or replace transfer pump.
Oil too low.	Add oil.
Oil relief valve not seating.	Clean by-pass. Replace if needed.
Badly worn bearings.	Replace.
Sludge on oil cup screen.	Remove and clean screen and oil reservoir.
Badly worn oil pump.	Replace.
HIGH OIL PRESSURE	
Defective oil pressure gauge.	Replace.
Oil too heavy.	Drain. Refill with proper oil.
Clogged oil passages.	Clean all lines and passages.
Oil relief valve stuck.	Clean by-pass. Replace if needed.
EXCESSIVE OIL CONSUMPTION - LIGHT BLUE SMOKY EXHAUST	
Poor compression. Usually due to worn piston, rings, or cylinder.	Refinish cylinder. Install oversize piston and rings.
Oil too light or diluted.	Drain. Refill with proper oil.
Too large bearing clearance.	Replace bearings necessary.
Engine misfires. Usually due to leaky valve or broken valve spring.	Reseat or replace as needed.
Faulty injection timing.	Check injection pump timing.

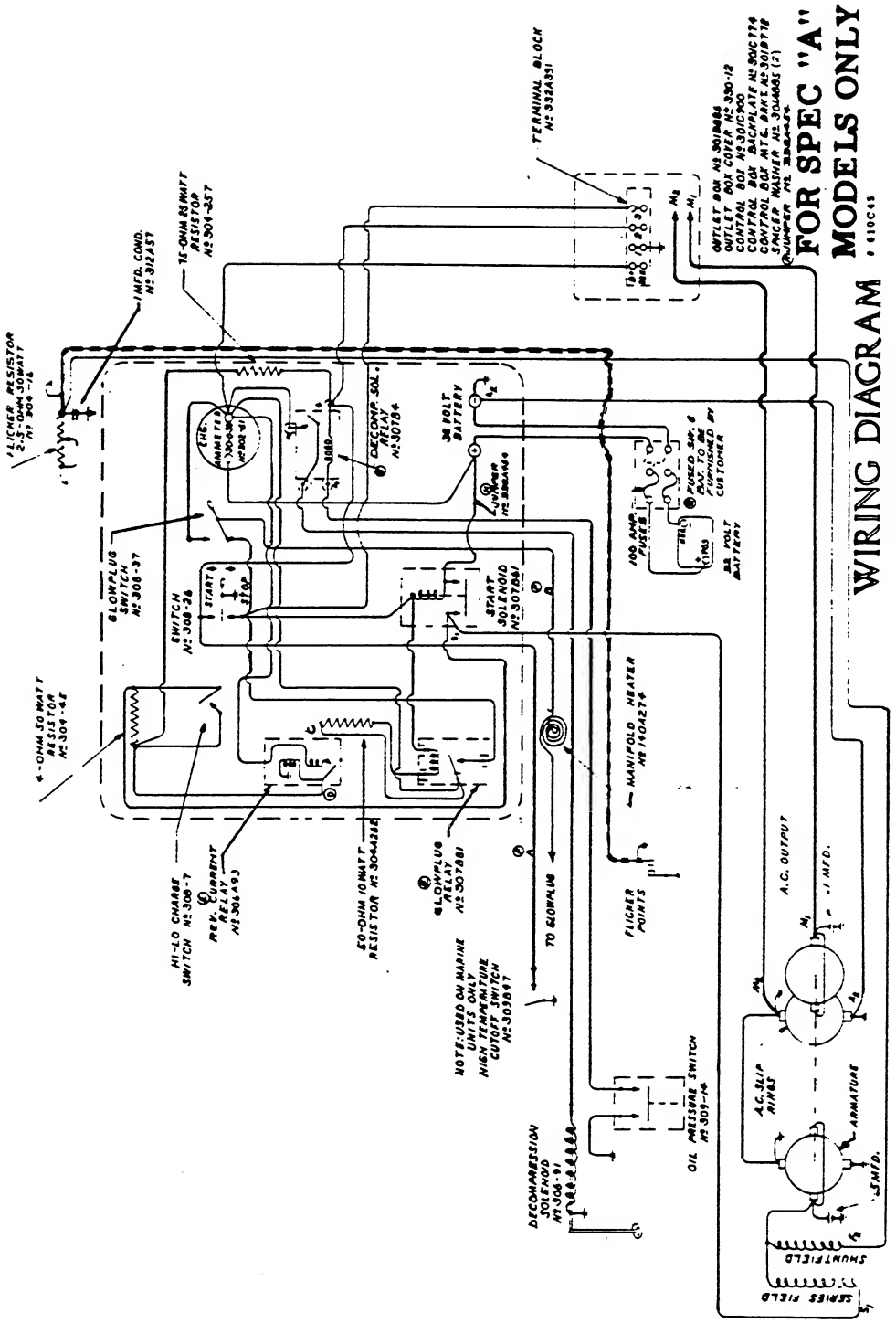
(Continued)

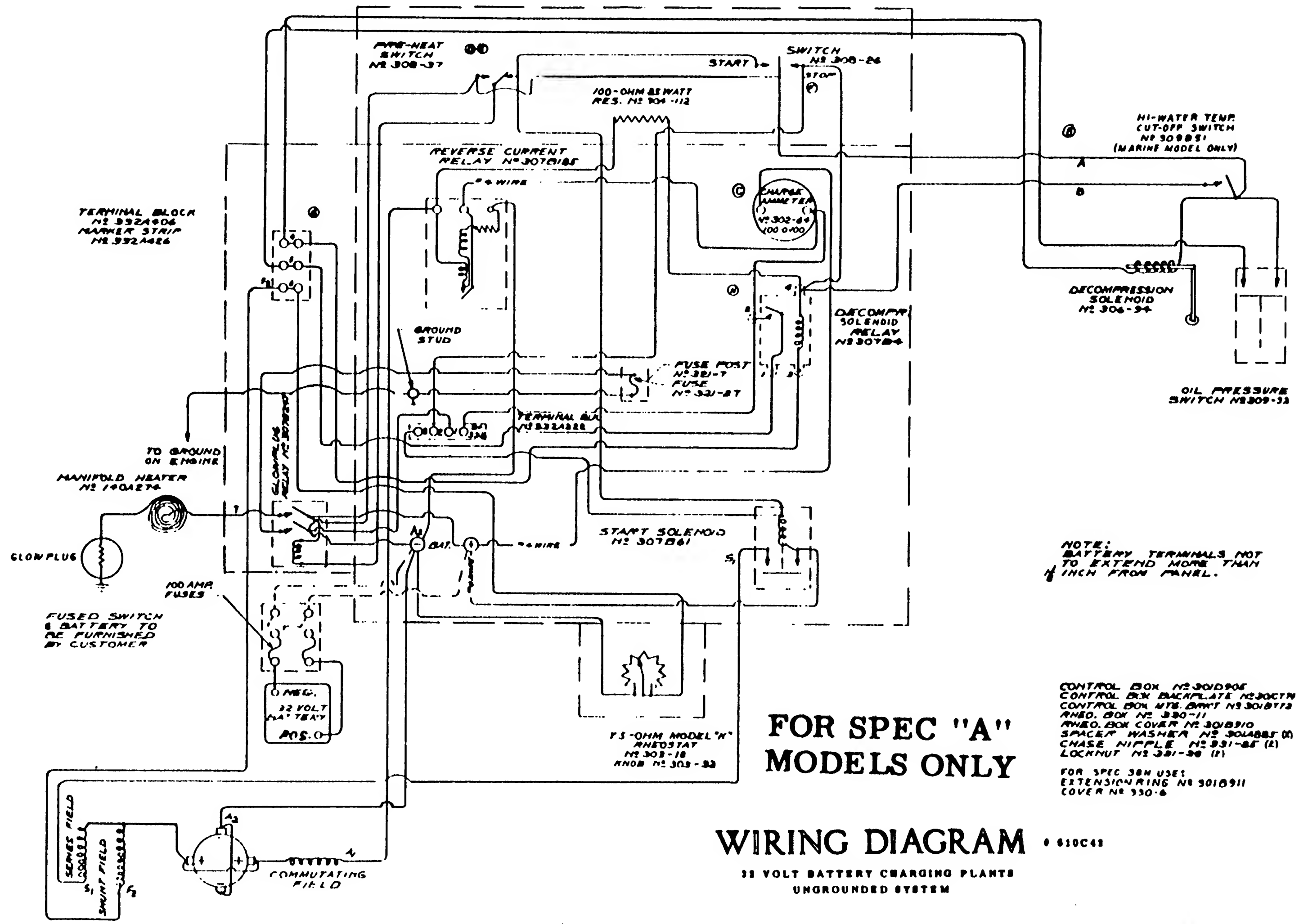
POSSIBLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION - LIGHT BLUE SMOKY EXHAUST	
Too much oil in cylinder block.	Drain excess oil.
Crankcase breather valve sticking.	Free up disc. Replace valve if necessary.
Air leak at oil filler cap gasket.	See that cap fits tightly and gasket is O.K.
BLACK, SMOKY EXHAUST - EXCESSIVE FUEL CONSUMPTION - POSSIBLE LACK OF POWER UNDER LOAD	
Generator overloaded. Black smoky exhaust normal condition with overload.	Reduce load to within rated capacity, If smoky condition does not clear up, stop the unit at once and check for further trouble. Serious damage may result if trouble is not corrected.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings - as needed.
Poor grade or dirty fuel.	Use only clean recommended fuel.
Injection pump or nozzle not operating properly.	Install new nozzle or injector pump.
Faulty injection timing.	Check injection pump timing.
ENGINE RACES	
Too much fuel being injected. NOTE: stop unit at once and determine cause.	Check condition and adjustment of governor, injection pump and nozzle.
Governor linkage disconnected.	Replace linkage. Tighten mounting nut securely.
ENGINE STOPS UNEXPECTEDLY	
Empty fuel tank.	Refill fuel tank as often as needed to prevent running out of fuel.

(Continued)

POSSIBLE CAUSE	REMEDY
ENGINE STOPS UNEXPECTEDLY (CONT.)	
Dirt in fuel system.	Use only recommended fuel. Install new filter element gasket. Clean fuel tank. Fill with clean fuel. Bleed fuel system. If trouble still not corrected, nozzle or injection pump may need replacing.
Decompression solenoid defective, improperly adjusted at rocker arm, or open solenoid circuit.	Operate solenoid manually or repair, adjust or replace parts needed. Check for adequate oil pressure.
Coolant temperature too high. Cut-off switch has operated.	Prime water pump. See that thermostat opens. Evidence of water to exhaust line may be only via the by-pass. Replace thermostat or pump parts if necessary. Allow time for engine to cool.
Oil pressure failure. Pressure switch has opened.	See Low Oil Pressure.
LIGHT POUNDING KNOCK	
NOTE: DO NOT CONFUSE WITH NORMAL KNOCK FROM FIRING OF FUEL.	
Loose connecting rod.	Adjust clearance or replace.
Low oil supply.	Add oil. Change if necessary.
Oil badly diluted.	Drain. Refill with proper oil.
Low oil pressure.	See Low Oil Pressure.
VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR UNIT	
Too small line wire used for load and distance.	Install larger or extra wires or reduce load.
MOTORS RUN TOO SLOWLY AND OVERHEAT AT FAR END OF LINE BUT RUN O.K. NEAR UNIT	
Too small line wire used for load and distance.	Install extra or larger wires or reduce the load.


WIRING DIAGRAM
FOR SPEC "A" MODELS ONLY
ALTERNATING CURRENT PLANTS
115 or 115/230 VOLT - 1 PHASE - 2 or 3 WIRE - 50 or 60 CYCLE.
TERMINAL BLOCK
1 MFD. COND.
15 OHM 10 WATT RESISTOR
FLICKER RESISTOR
GLOW PLUG SWITCH
START SOLENOID
JUMPER
11 VOLT BATTERY
2 6 VOLT BATTERIES IN SERIES
OUTLET BOX
OUTLET BOX COVER
CONTROL BOX
CONTROL BOX BACKPLATE
CONTROL BOX MTG. BRKT
SPACER WASHER
JUMPER
REV. CURRENT RELAY
GLOWPLUG RELAY
TO GLOWPLUG
FLICKER POINTS
OIL PRESSURE SWITCH
DECOMPRESSION SOLENOID
A.C. OUTPUT
AC SLIP RINGS
ARMATURE
SHUNT FIELD
SERIES FIELD
USE IN 115-230V. 1P JW PLANTS ONLY

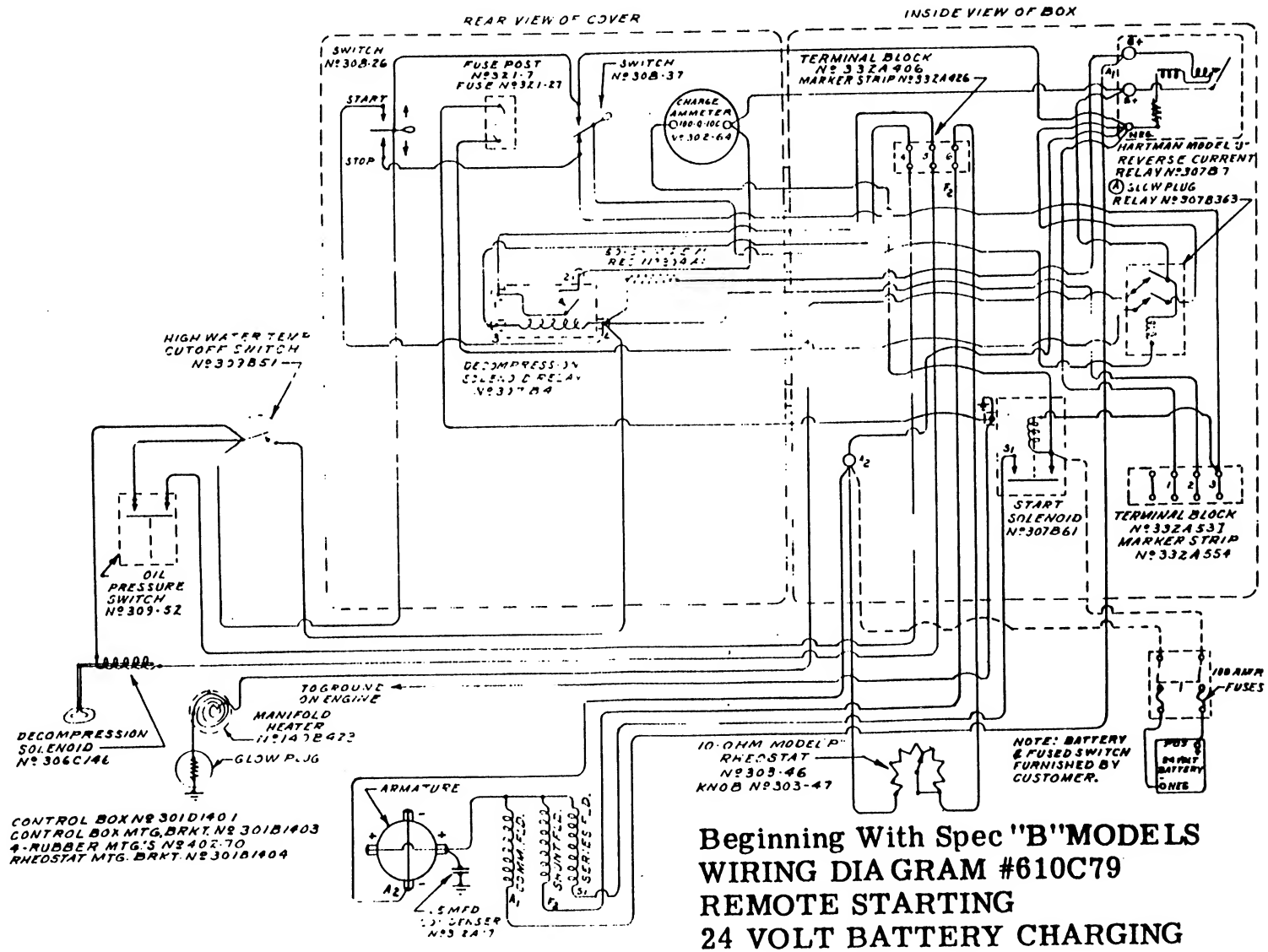

WIRING DIAGRAM
FOR SPEC "A"
MODELS ONLY
DUAL PURPOSE PLANTS:
12 VOLT DIRECT CURRENT
110 VOLT - 1 PHASE - 2 WIRE - 60 CYCLE - AC
FLICKER RESISTOR 2.5-OHM 30 WATT
INFD. COND.
75-OHM 85 WATT RESISTOR
TERMINAL BLOCK
OUTLET BOX
OUTLET BOX COVER
CONTROL BOX
CONTROL BOX BACKPLATE
CONTROL BOX MTG. BANT
SPACER WASHER
DECOMP. SOL. RELAY
12 VOLT BATTERY
GLOWPLUG SWITCH
SWITCH
START
STOP
START SOLENOID
100 AMP FUSE
FUSED SW. & BAT. TO BE FURNISHED BY CUSTOMER
4-OHM 50 WATT RESISTOR
MANIFOLD HEATER
HI-LO CHARGE SWITCH
REV. CURRENT RELAY
50-OHM 10 WATT RESISTOR
GLOWPLUG RELAY
NOTE: USED ON MARINE UNITS ONLY HIGH TEMPERATURE CUTOFF SWITCH
TO GLOWPLUG
FLICKER POINTS
A.C. OUTPUT
1 MFD.
A.C. SLIP RINGS
ARMATURE
5 MFD.
SHUNT FIELD
SERIES FIELD
DECOMPRESSION SOLENOID
OIL PRESSURE SWITCH



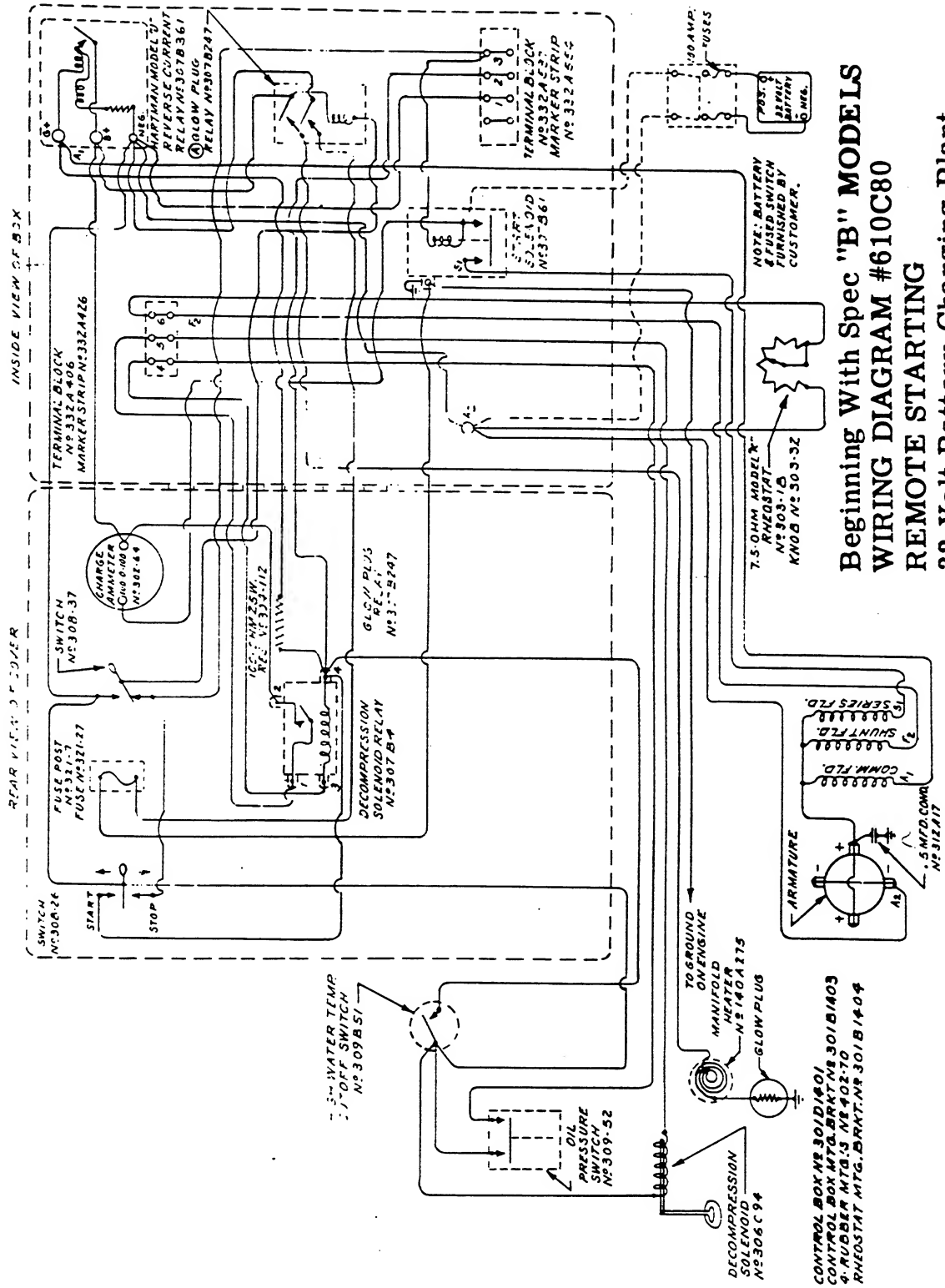
FOR SPEC "A" MODELS ONLY

WIRING DIAGRAM

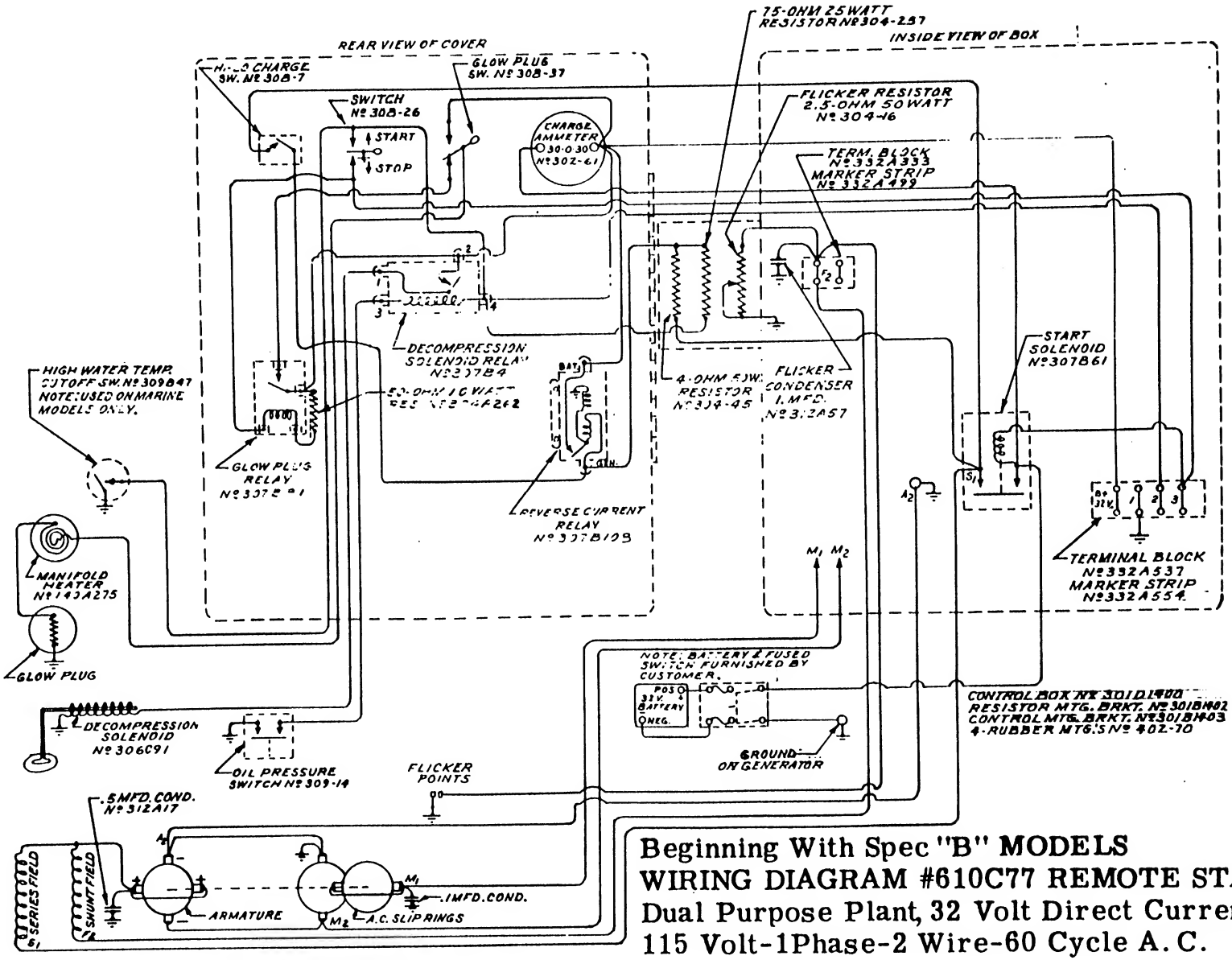
32 VOLT BATTERY CHARGING PLANTS
UNGROUNDED SYSTEM



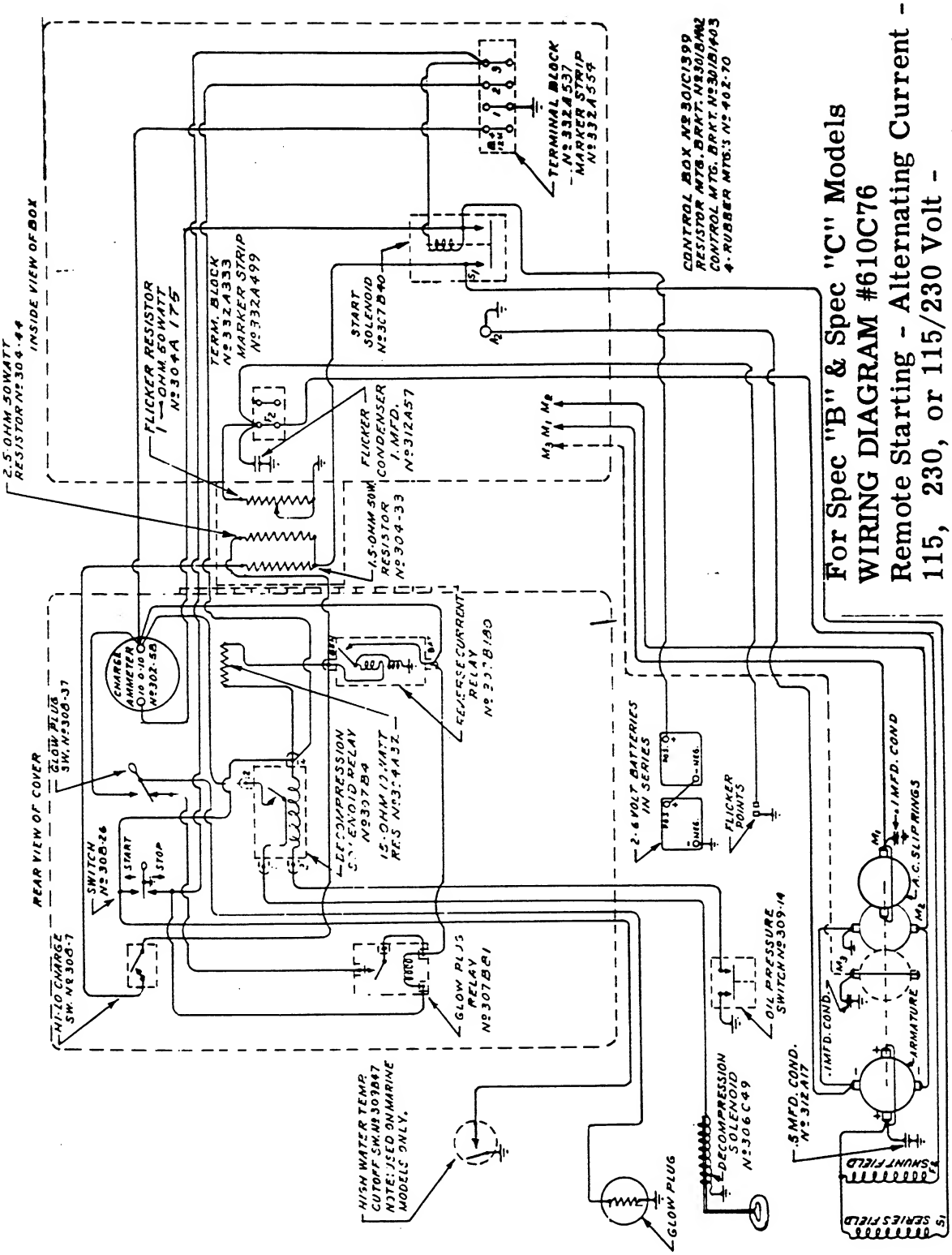
Beginning With Spec "B" MODELS
WIRING DIAGRAM #610C79
REMOTE STARTING
24 VOLT BATTERY CHARGING

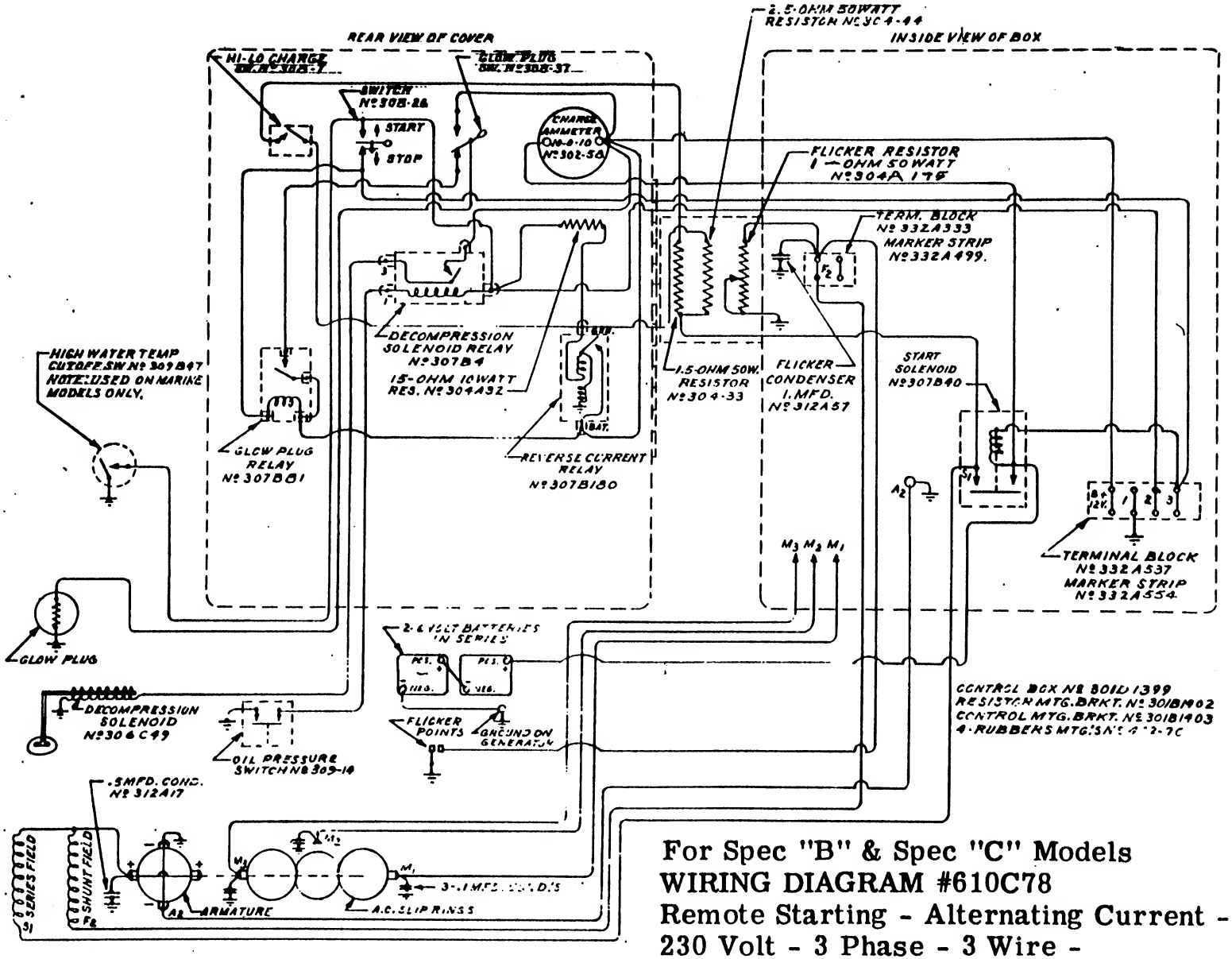


Beginning With Spec "B" MODELS
WIRING DIAGRAM #610C80
REMOTE STARTING
32 Volt Battery Charging Plant

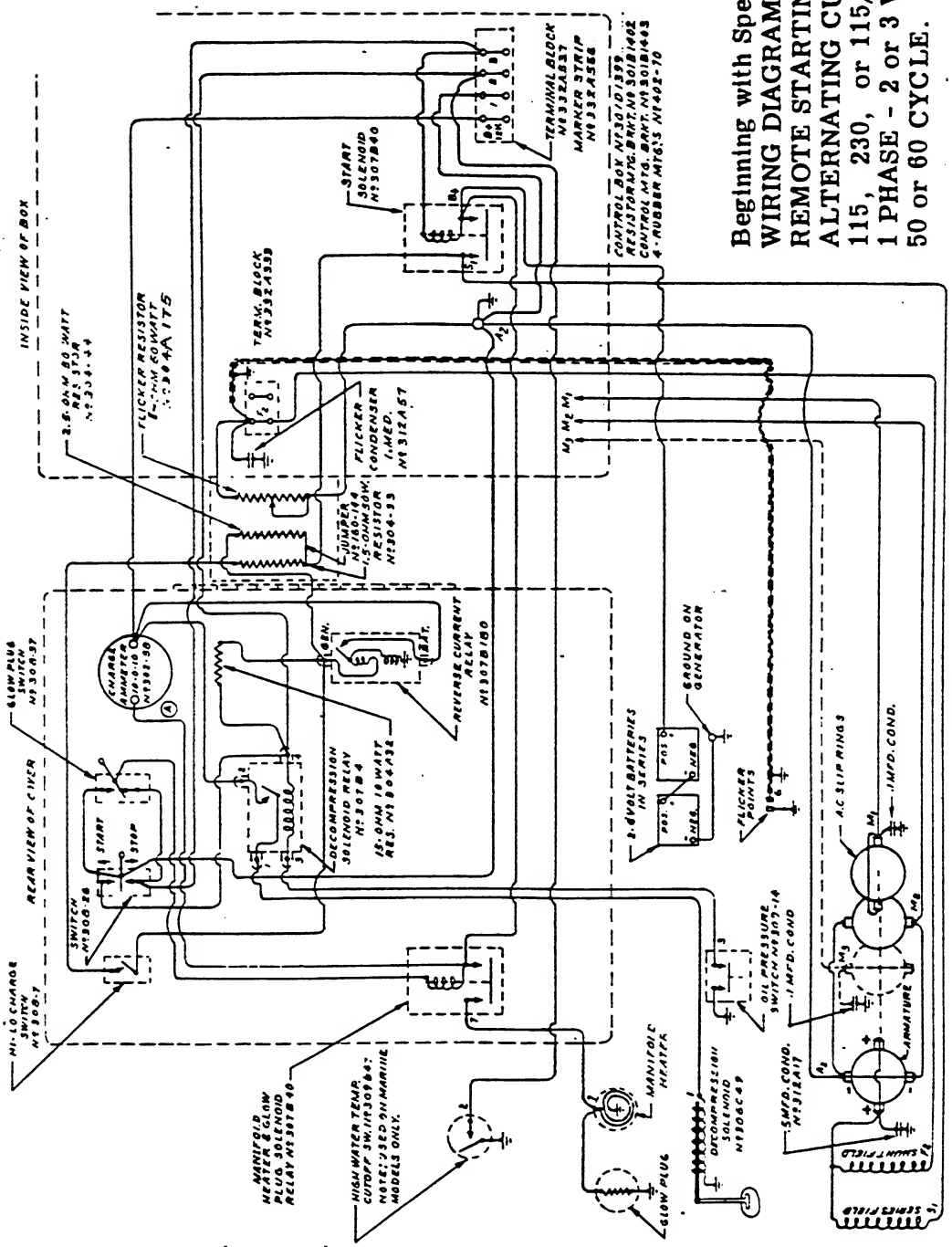


Beginning With Spec "B" MODELS
WIRING DIAGRAM #610C77 REMOTE STARTING
Dual Purpose Plant, 32 Volt Direct Current
115 Volt-1Phase-2 Wire-60 Cycle A. C.

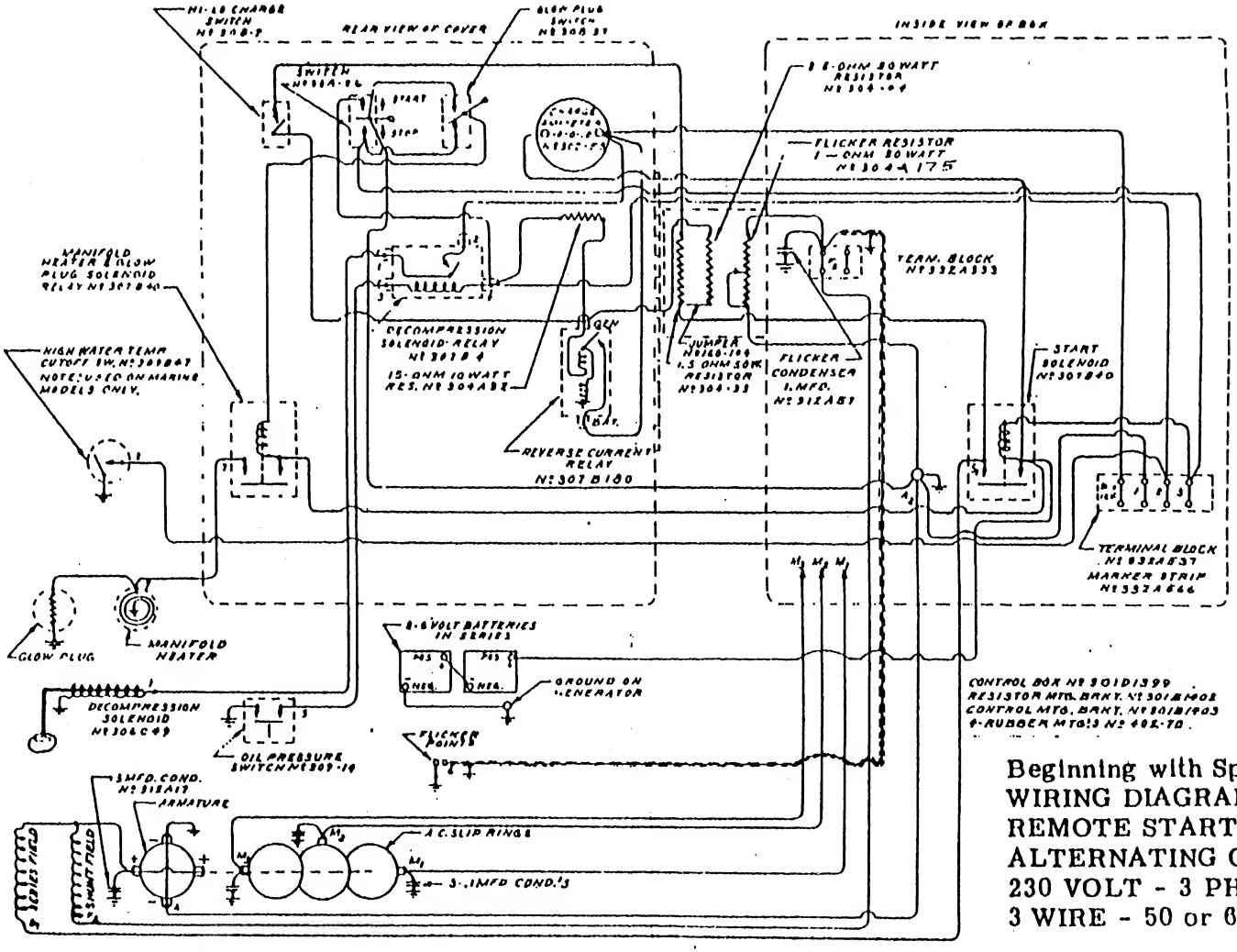

For Spec "B" & Spec "C" Models
WIRING DIAGRAM #610C76
Remote Starting - Alternating Current -
115, 230, or 115/230 Volt -
1 Phase - 2 or 3 Wire - 50 or 60 Cycle.
REAR VIEW OF COVER
INSIDE VIEW OF BOX
2.5 OHM 50 WATT RESISTOR Nº 304-44
FLICKER RESISTOR 1 OHM, 60 WATT Nº 304A 175
TERM. BLOCK Nº 332A333 MARKER STRIP Nº 332A499
START SOLENOID Nº 367B40
TERMINAL BLOCK Nº 332A537 MARKER STRIP Nº 332A559
CONTROL BOX Nº 30C1399
RESISTOR MTG. BRKT. Nº 130/8MM2
CONTROL MTG. BRKT. Nº 30/8/403
4 RUBBER MTGS. Nº 402-70
FLICKER CONDENSER 1 MFD. Nº 312A57
15 OHM 50W RESISTOR Nº 304-33
CHARGE AMMETER Nº 302-56
GLOW PLUG SW. Nº 308-37
SWITCH Nº 308-26
HI-LO CHARGE SW. Nº 308-7
DECOMPRESSION SOLENOID Nº 303B4
15 OHM 12 WATT RES. Nº 304-32
RELEASE CURRENT RELAY Nº 303B190
GLOW PLUG RELAY Nº 307B21
2-6 VOLT BATTERIES IN SERIES
FLICKER POINTS
OIL PRESSURE SWITCH Nº 309-14
DECOMPRESSION SOLENOID Nº 306C49
HIGH WATER TEMP. CUTOFF SW. Nº 309B47
NOTE: USED ON MARINE MODELS ONLY.
GLOW PLUG
.5 MFD. COND. Nº 312A17
1 MFD. COND.
ARMATURE
A.C. SLIP RINGS
.1 MFD. COND.
SHUNT FIELD
SERIES FIELD



For Spec "B" & Spec "C" Models
WIRING DIAGRAM #610C78
Remote Starting - Alternating Current -
230 Volt - 3 Phase - 3 Wire -
50 or 60 Cycle.



Beginning with Spec D models.
WIRING DIAGRAM #610C88
REMOTE STARTING -
ALTERNATING CURRENT -
115, 230, or 115/230 VOLT -
1 PHASE - 2 or 3 WIRE -
50 or 60 CYCLE.



Beginning with Spec D models.
WIRING DIAGRAM #610C87
REMOTE STARTING -
ALTERNATING CURRENT -
230 VOLT - 3 PHASE -
3 WIRE - 50 or 60 CYCLE.

PREPARING UNITS FOR STORAGE OR EXTENDED OUT-OF-SERVICE PERIODS

Electrical generating plants are often taken out of service for extended periods of time. Plants remaining out-of-service more than 30 days should be protected against rust, corrosion, or the elements.

The cooling system should be flushed, drained and a warning tag attached.

If the lubricating oil is dirty, drain it while hot, install a new filter element and attach a warning tag.

Remove the glow plug to pour two tablespoonfuls of rust inhibitor oil (or SAE 50 as alternate) into the cylinder. Slowly crank the engine to lubricate the cylinder, then stop at top center. Replace the glow plug.

Wipe all exposed parts clean and coat with a film of grease all such parts liable to rust.

Disconnect the battery from the plant. An idle battery should be stored away from freezing temperatures and should be given a refreshening charge about every 40 days.

Clean generator brushes, brush holders, commutator and collector rings by wiping with a clean cloth. DO NOT coat with lubricant or other preservative !

The fuel supply and fuel system should be left filled but any possibility of fuel syphoning should be guarded against.

Plants being returned to service should be prepared according to preparation instructions for a new plant.